HOW TO KNOW TEXTILES

SMALL

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BY

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PREFACE

This book is designed primarily as a textbook for students in high schools and universities. Its purpose is to give a practical working knowledge of textiles in such a simple and concrete way as will arouse an interest in the many fabrics required in daily life.

The aim of this book, however, is not limited to an interest in textile fabrics. In the chapters on raw materials the text not only suggests the interdependence of the many countries of the world for these products, and the effect of any great disturbance or disaster, but it also attempts to stimulate patriotism by pointing out the resources of our own great country and the opportunity of further developing and conserving them. In the description of the manufacturing processes a new vision of the subject is given by a presentation of the amount of time, labor, brains, and money necessary to make the vast quantity of finished product required by the host of cloth consumers.

Many of the teaching devices given are original with the author, who has used them successfully with students widely differing in age and educational background. A large number of the illustrations, which assist in interpreting the descriptions, have never before appeared in a textbook.

Throughout the book the author has endeavored to make the subject practical and educational as well as interesting. It would seem, therefore, that this volume should be of value not only to students in schools but to women in homes, to buyers and salespeople in stores, and to all others whose business it is to buy, sell, or use textile materials.

CASSIE PAINE SMALL

PREFACE TO ENLARGED EDITION

Since the first appearance of this book, the world has advanced rapidly in the application of scientific discoveries to the practical needs of man. In line with this progress, the field of textiles has experienced many changes. The textile world has passed through an almost complete reorganization through its acceptance and promotion of a new material,—rayon,—our only textile fiber made by man. Shunned at first as unattractive and unworthy, rayon has so responded to the persistent efforts for its improvement by practical scientists that it has risen rapidly to a permanent and respected place among the world's textile fibers.

To give the story of the spectacular growth of this textile prodigy is the purpose of the chapter "Rayon, a Chemical Triumph," which is now added to the book.

CASSIE PAINE SMALL

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It would be well-nigh impossible to give the names of the many students, coworkers, and other friends who have aided in the preparation of this work. To all these the author wishes to express her full appreciation.

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Much help has been received from the United States Department of Agriculture through its various experiment stations in the different states. To Mr. Lyster H. Dewey, Botanist in Charge of Fiber Investigations, Bureau of Plant Industry, United States Department of Agriculture; Mr. A. H. Wright, Assistant Professor of Agronomy, College of Agriculture, the University of Wisconsin; Mr. H. L. Bolley, Dean of the North Dakota Agricultural College; Mr. J. A. Hill, Wool Specialist, University of Wyoming; Mr. R. B. Millin, Livestock Specialist, College of Agriculture and Mechanic Arts, University of Montana; Mr. F. W. Gish, Agricultural Statistician, Bureau of Crop Estimates, United States Department of Agriculture, Montgomery, Alabama; and Mr. J. M. Jones, Chief of Division of Animal Industry, Texas Agricultural Experiment Station; also to Mr. W. H. Teasdale, secretary and superintendent of Savannah Cotton Exchange, and Mr. W. W. Morrison, secretary of Galveston Cotton Exchange and Board of Trade, the author is indebted for much information concerning the production of textile raw materials in the United States.

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SUGGESTIONS TO TEACHERS

Occasionally a most conscientious and painstaking teacher is heard to remark, "Yes, I give a course in textiles, but, frankly, the pupils are not interested in it." When this condition exists, the course is of little practical benefit to the pupils and is the most disheartening drudgery for the teacher.

A study of the history of many of the common things of daily life often discloses a story of romance, tragedy, and heroism. In the history of the evolution of cloth and its entrance into our world of necessities such stories abound. In this book the author has attempted to reveal some of the rich store of human associations connected with a piece of cloth, thereby making the study of textiles a broad and interesting course for the pupils, and she has suggested methods of so presenting and enriching the text of the book that the teaching of this subject may be a real pleasure.

It is possible for textiles to be taught without equipment other than that found in the average schoolroom. The fabrics to be studied can be furnished by the clothing of the pupils and the garments and scraps of cloth brought from home. The reference books can be supplied by the public library, and the few pieces of scientific apparatus can usually be borrowed from some other department in the school. A simple loom can be made at home, and an ordinary school notebook can be used for mounting and labeling the cloth specimens studied.

In many high schools there is no scheduled course in textiles, but some instruction in cloth is given in connection with the sewing and retail-selling classes. The author has kept such schools in mind and has endeavored to give sufficient material in the text of the book, together with the glossaries, questions,

and assignments, for a practical study of fabrics. For high schools, colleges, and universities, however, where there is a prescribed course in textiles, much more satisfactory work can be accomplished if a few pieces of apparatus are furnished and special privileges for the study of this subject are given.

The class in textiles should have the use of a loom of some kind, a compound microscope, a thread-counting micrometer, and a simple dyeing and testing outfit consisting of a Bunsen burner (or some other heating device), a kettle, glass rods, etc. There should be in the school library several cloth dictionaries and other reference books on textiles, and at least one trade paper. The teacher should be allowed a certain amount of money for cloth samples, mounts, pictures, pamphlets, exhibits, and materials for dissection, dyeing, and testing. She should be permitted to substitute, for the regular classroom exercises, visits to factories, stores, textile schools, and museums, as special phases of the subject can be studied only in this direct way.

For this course the class should have an opportunity to see moving pictures of cloth manufacture. Many large firms throughout the country have prepared films in which the marvelous operations connected with the manufacture of their particular products are vividly portrayed. A school can usually secure the use of these films with little trouble and expense, and by means of a small moving-picture machine a "movie" with an educational content but with all the thrills of a real "show" may be given at any time in the classroom. Where it is not possible to obtain the equipment for moving pictures, much graphic instruction can be given by means of a reflectoscope with post cards and other textile pictures.

So far as possible a course in textiles should be correlated with the other courses being taken by the pupils. The desirability of such correlation is very evident in some chapters of the book; for instance, in Chapter VII, the need of the history department is shown; in Chapters VIII and IX, the art depart-

---------------------- CLOTH

NAME --

APPEARANCE --

COLOR --------------------- VARIATIONS -------------

WIDTH --------------------- VARIATIONS -------------

KIND OF WEAVE ----------- VARIATIONS -------------

CHARACTER OF YARN -----------------------------------

WARP ---

FILLING --

PRICE --------------------- VARIATIONS -------------

PLACE AND DATE OF PURCHASE ------------------------

USE ---

STUDY CARD

The card is 5 inches × 8 inches in size. There is a $2\frac{1}{2}$ inch space at the left for the mounting of the sample, beside which the required information is to be recorded. The card shown is for the study of fabrics made from the different fibers, the dotted line before the word "Cloth" being used for the name of such fiber, as "*COTTON* CLOTH." The printed headings at the right of the sample are the points to study for identification of the particular material

ment; in Chapter XI, the chemistry department; and in Chapters XII–XVI inclusive, the commercial-geography department.

A collection of cloth samples has been required in many of the assignments. The procuring of these samples by the pupils usually demands a variety of social contacts and furnishes one of the richest educational opportunities of this course. The method of preserving and arranging this material by the pupils so as to be available for study at any time is, however, a problem for the teacher.

All samples should be large enough so that they will give a good idea of the character of the cloth and can easily be handled for study. A minimum size of $1\frac{1}{2}$ inches by 3 inches is sug-

gested, but larger pieces of certain fabrics are desirable. These samples should be mounted in an orderly way, and information concerning them neatly recorded. This may be done on sheets of paper or cardboard of any uniform size, fastened together in any manner. Printed study cards like the one suggested form a very convenient way of keeping intact these small pieces of cloth.

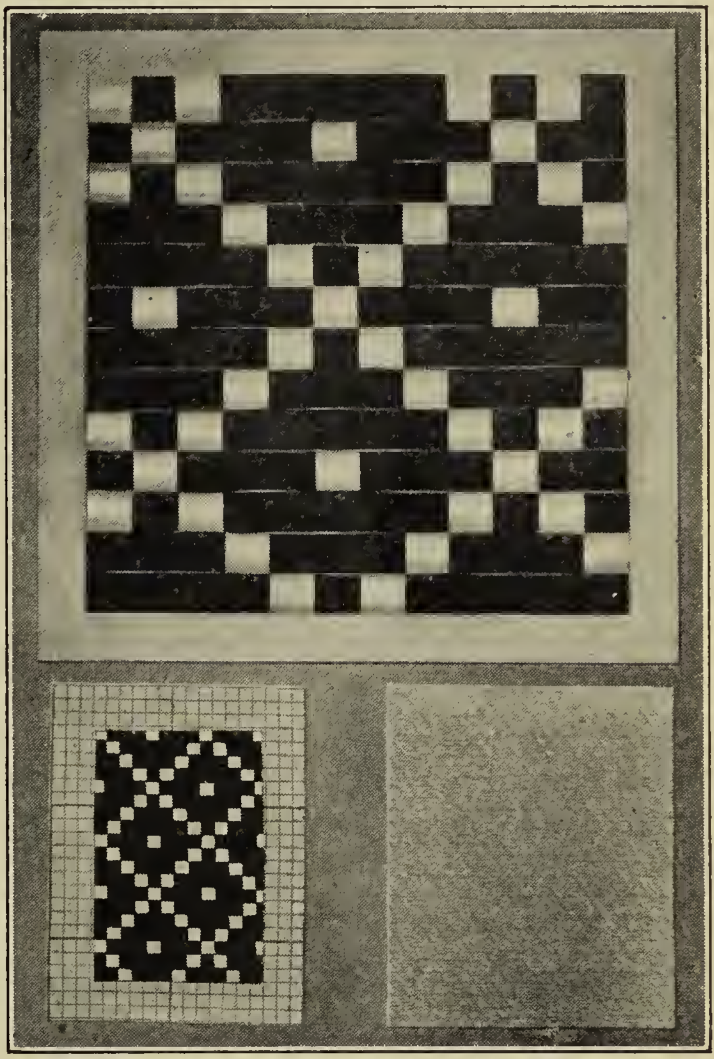
A teacher may find it desirable to change the wording on the cards, thus requiring other points of study than those given; or she may prefer unprinted cards, as they can be used for mounting and labeling the samples studied for other phases of the subject, as the composition of the cloth, its method of construction, coloring, etc.

For the teacher's collection of cloth the samples should be large enough to give an idea of the fabric as it would appear in the piece or in the garment. If bought for the purpose, the pieces should be from an eighth to a quarter of a yard in length. They would best be left unmounted, but can be labeled with complete information by means of good-sized string tags or folding pin tickets. In order to appreciate the construction of cloth each pupil should do at least three samples of weaving. The manual-training department may assist in the course by making some simple looms for the class. One that can be made at home from a cigar box is shown on page 23. By the use of a primitive harness (heddle, it is called) and a small shuttle the three operations required for plain weaving can be executed. Where even this simple loom cannot be obtained, the construction of cloth can be worked out with kindergarten weaving mats, a mat of one color being used to represent the warp, and strips of a contrasting color the filling.

Every school in which courses in textiles are given, however, should possess a loom on which a useful piece of cloth can be woven. A Colonial hand loom is the most desirable kind, but these are expensive and cumbersome, and a portable loom forms a very good substitute. There are a number of such looms on the market at the present time.

The analysis of different weaves furnishes an added appreciation of cloth structure. The samples for this study should be of rather coarse yarns, with the weave clearly shown. Pieces from garments or household fabrics that have been laundered many times or are well worn furnish good specimens for weave analysis.

With the aid of a weaver's glass and a needle the path of a filling yarn through the warp yarns can be followed and recorded on cross-section paper, using a dot or a cross to show where it passes over the warp. By blocking in these squares the cloth design can be made on the paper and afterwards woven with yarn or weaving mats. The accompanying illustration shows such a study of the familiar bird's-eye, or diaper, weave.



WEAVE ANALYSIS OF BIRD'S-EYE LINEN

The necessity of the constant use of the public library in connection with this course is shown by the lists of references accompanying each chapter. These lists comprise a wide field of reading selected from a great variety of sources. Most of the books and magazines, both scientific and popular, can be found in any well-equipped library. Where this is not possible the

teacher can render real service to the community by suggesting to the librarian a list of books on the subject of textiles. The trade papers mentioned can usually be found in the local stores, in textile manufacturing plants, and in the schools and colleges where the practical arts are taught. All the authorities that have been interviewed by the author have been most generous in sharing this literature with textile students or assisting them in securing it for themselves.

The pamphlets and articles chosen have purposely been selected from many kinds of publications. They include much advertising matter, most of which is gladly given for the asking. It is impossible to estimate how much valuable information is distributed by business and manufacturing firms of the present day through educational advertisements.

By the preparation of interesting and technical bulletins on the subject of textiles the technical schools, state colleges, and universities throughout the country are rendering a great educational service. New literature of this kind is constantly appearing from these sources, the securing of which will give the teachers throughout the state an opportunity to keep in touch with the latest methods and discoveries of their higher institutions of learning. These bulletins are usually free to anyone living in the state.

The United States Department of Agriculture, Washington, D.C., is perhaps the greatest source of information for this study. Records of years of scientific research and wide experimentation are obtainable in a form designed to give the inquirer on this subject the accurate and authoritative information that he is seeking. Every teacher should become acquainted with the educational resources of this great department of our government.

A perusal of the contents of this book will show that the study of the subject of textiles has, at every turn, been approached by an examination and study of the fabrics required in our daily life. The close connection between the study of textiles as a school subject and the study of textile materials found in our

homes and stores cannot be too strongly emphasized. No course in textiles is complete without this happy combination: the technical knowledge to be gained from books and classroom instruction, and the practical knowledge to be gained by handling cloth and obtaining information from those who know textile materials.

This method of approach should aid in rendering the subject of textiles purposeful. When this aim is accomplished, the feeling on the part of the pupils that textiles is "a course to be taken" will be replaced by a real interest in the subject and a desire to know more about cloth, the use of which is so universal and the production and distribution of which form such an important factor in our industrial and financial world.

A FULL-RIGGED SHIP

These picturesque vessels have almost entirely disappeared as engines and motors have taken the place of sails, but much textile material is still needed in the equipment of all kinds of water craft. (Courtesy of Captain L. B. Lovejoy)

HOW TO KNOW TEXTILES

CHAPTER I

OUR GREAT VARIETY OF FABRICS

The changing world of cloth. If we were to give the names of all the varieties of fabrics found in mills, stores, and homes at the present time, we should find the list almost endless. It would be very different from the one that our grandmothers could have compiled in their girlhood forty or fifty years ago. Several very common kinds of cloth of those days are not now to be found in our stores or homes, and we have many materials today that were never heard of or imagined when our grandmothers were girls. As many changes would doubtless be evident if we could inspect the fabrics being used forty or fifty years hence. Probably some of the cloths that we are now using will have entirely disappeared then, and their places will have been filled by materials of which we have no conception. Nearly every year new kinds of cloth appear on the shelves of our retail stores and are found made up into garments in our ready-to-wear departments, while every year certain materials that have been familiar to us in the past are difficult or impossible to obtain.

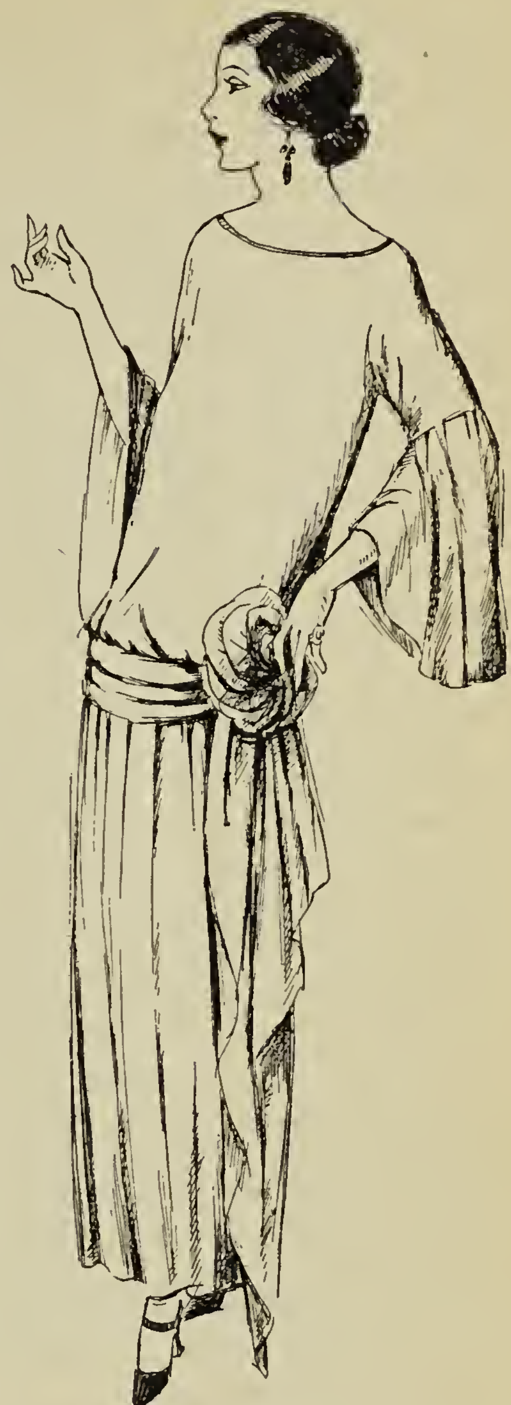
Varieties of cloth governed by nature of demand. Why is there such a changing flux in the cloth world? It requires an expenditure of much ability, labor, time, and money to design and make a new textile material,[1] put it on the market,

[1] The term *textile materials* is the general name for all forms of thread, yarn, or fabric.

and introduce it to the public. Note in the textile and trade journals the amount and quality of advertising given to any new kind of cloth that is making its appearance. The cost of advertising alone, when an addition is made to our world of cloth, is far greater than we probably have ever imagined; yet, with the most forceful advertising, the popularity of the material is sometimes only short-lived. This condition seems true of the widely advertised cartridge silk of 1919–1920. In less than two years people almost forgot that there was such a material as cartridge silk, while its companion, airplane linen, which appeared at about the same time, was still appreciated by those who bought it, and sought after by those who were not so fortunate. Why, then, do not fabrics that were once popular continue to live, and why does any manufacturer venture the thrusting of a new cloth into an already much-crowded cloth world? The answer is simply this: the appearance of a new kind of cloth or the longevity of a well-known kind depends upon a demand for that particular material by those who are to use it, — the great buying public.

1. *Varieties for utility.* There are different kinds of demands among cloth users, and these demands determine what fabrics shall be manufactured and sold. The strongest and most constant cloth demand of people in general is for enduring materials that have proved themselves to be the best and most adaptable fabrics for the common needs of daily life. Examples of such materials are crash and huckaback for towels; scrim for curtains; cretonne for hangings; batiste, nainsook, and longcloth for baby clothes and underwear; madras for shirts; percale and gingham for aprons and wash dresses; serge and broadcloth, taffeta and foulard, for gowns; tweeds and worsteds for men's and boys' clothes. These cloths are usually spoken of as staple materials and are nearly always carried in our stores. They bear the same name wherever found, and their uses remain constant from

year to year. We think of these cloths as old and reliable materials. They are what our mothers have tried and recommend to us, and their names are so common that even those of us who know nothing about cloth have at least heard of these fabrics. Many of our staple materials have been manufactured for years by the same firms, whose names they often bear.



DAME FASHION'S EDICT FOR A RECENT YEAR, AS SHOWN BY THE STYLE ADVERTISEMENTS OF THAT YEAR

2. *Varieties demanded by fashion.* Another strong demand that determines what new fabrics shall appear is the style demand. When Dame Fashion decrees that the lines of the figure shall be long and straight, then we see jersey, tricolette, charmeuse, Canton crêpe, Georgette, and other limp materials that will drape easily and give such lines. The straight silhouette of the figure is further accentuated by thin, clinging underwear, and silk or soft muslin is used for these garments, instead of materials with a stiff finish. Jersey silk petticoats are worn instead of taffeta, and, to continue the style effect, soft, "wrappy" materials like bolivia and duvetyn are used for coats and outer garments instead of tweeds and heavy worsted coatings. If Dame Fashion says "short skirts," then

silk stockings are in demand, and people who perhaps never before indulged in such a luxury conform to the fashion standards of the day. A sudden addition to the wearers of silk stockings causes a vast increase in the demand for such hose, with a consequent increase in production. During the reign of the short skirt it is said that about 80 per cent of the hose manufactured for women was of silk.

If we were to study the different articles in our wardrobe today and compare them with those of only a few years ago, we should become more fully aware of the power of the style demand in determining what kinds of cloth shall be manufactured. Dame Fashion also dictates to a large extent what kinds of cloth shall be used for upholstery materials and household furnishings. At one time she decrees that our homes shall have a stiff and stately appearance, and much haircloth is used; she may favor an ornate effect, and velour and plush are found everywhere; or she may yield to a demand for comfort and quiet elegance, and tapestry is the favored upholstery material. In our linen she may influence the pattern or the decoration of the article. At one time she may allow towels of the damask weave; then she may withdraw this demand and require the huckaback. In our tablecloths she may approve of a large, bold design or of small, delicate tracery. She may require us to be surrounded by much lace and fluffiness or she may permit us to be happy with simple, plain edges on the cloth articles that we possess.

This constant changing of the kinds of cloth favored by fashion has much influence upon the prices of materials. In the height of style a fabric will sometimes bring twice as much as when a newer material has usurped its popularity. The rise in price of a material that is smiled upon by this fickle goddess is also quite remarkable. A striking instance of this kind fell within the experience of the writer a few

years ago. In a certain year before the World War a certain well-known firm in London was introducing a new dress fabric. It was a mixture of artificial silk and other fibers and could be obtained at their stores in black, white, and a number of popular colors. The cloth bore a specific trade name and was priced at 3/11 (3 shillings, 11 pence), English money, or about 95 cents a yard in United States money. Four years later one of the largest retail stores in the United States printed a most interesting advertisement of a new fabric (giving its name) just obtained of a London firm, of which they were the sole importers. It was obtainable in two colors, black and white, and the price was $4.50 per yard.

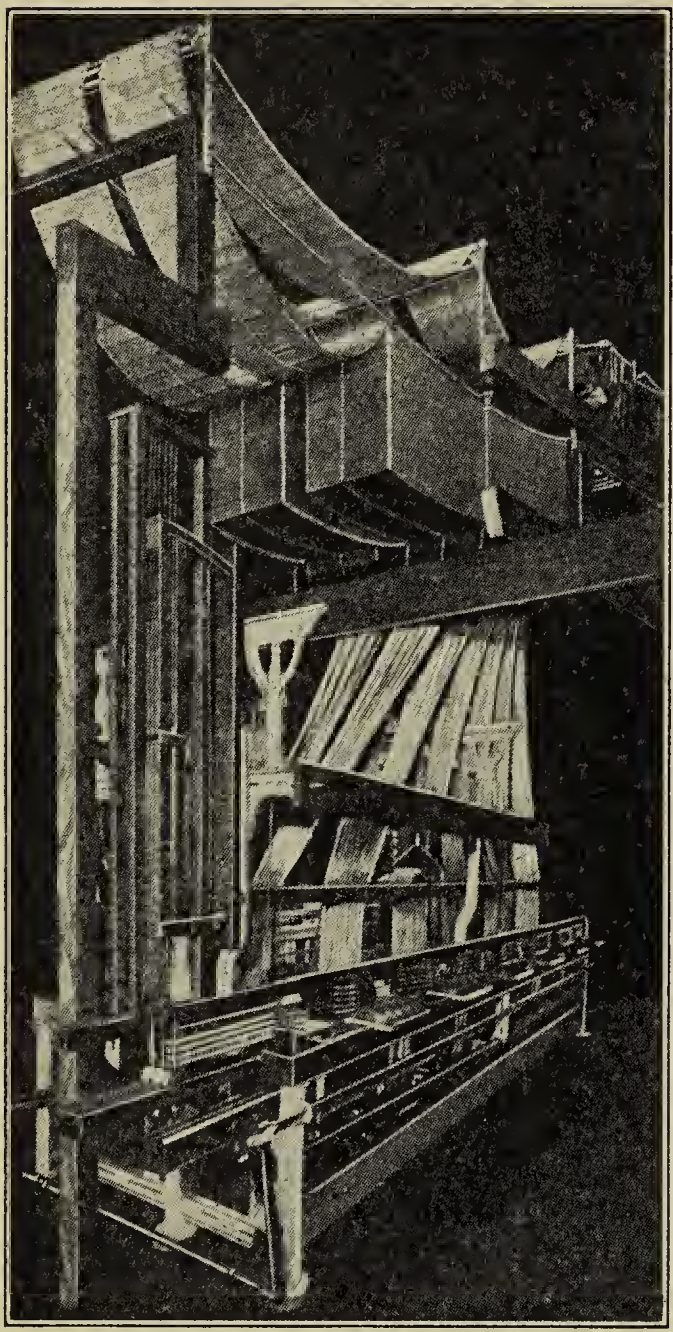
One can now readily see why those materials whose popularity is governed almost entirely by the caprices of fashion are called style fabrics. Because of the expense involved in creating so many fabrics in order that a few may live, they must bring a relatively higher price. This startling statement appears in a book which traces the important steps in the introduction of new styles:

> When the mannequins appear at the Paris races, the fabric is as much an object of study as is the cut of the garment. The materials which are displayed in this way represent a selection from a wide variety of fabrics which have been created on an experimental basis. Out of one thousand designs worked out each year in one house, perhaps fifty will live, and this is not considered discouraging.[1]

And a pamphlet from a large woolen and worsted manufacturing company in this country states that from the products of their mill "more than thirty-five thousand styles of fabrics are shown each season."

3. *Varieties for specific purposes.* There are certain specific demands that add their mite toward swelling the great

[1] Cherington, The Wool Industry, p. 170.



THE LOOM ON WHICH A RIBBON SOUVENIR WAS WOVEN

Courtesy of Johnson, Cowdin and Company, Inc.

variety of kinds of cloth produced. The weaving of cloth labels, banners, all kinds of insignia, and special souvenirs illustrates a part of the highest endeavors of artistic construction. Such decorative materials are used, for the most part, for special purposes and at particular times. Labels are generally made to designate the product of special manufacturers; therefore only a limited quantity of any one kind is produced at the same time. Banners, badges, bands, etc. are generally consumed by various organizations (patriotic or fraternal), the number required being governed by the size and activity of the organization. The purpose of the cloth souvenir is frequently to advertise something, and always to mark some particular event in business or civic life. Elsewhere in this book a description is given of a wonderful piece of weaving, by a New Jersey silk manufac-

turer, that was used as a souvenir at the Panama-Pacific Exposition in California in 1915. This achievement in cloth construction was considered so remarkable that the Smithsonian Institution at Washington, D. C., asked for the original design to add to its collection of striking illustrations of American skill and genius. The making of such materials usually involves a vast amount of labor and expense, entirely out of proportion to the length of life and apparent usefulness of the article. This specific demand, though short-lived, is nevertheless imperative, and the addition to the cloth world of this special kind of artistic production is a matter of pride to our American manufacturers.

It has been customary at times in our history to confer a high compliment upon some noted or favored individual by making a material for his use alone. At the time of President Wilson's inauguration in 1913 a beautiful piece of brocade was made by another American silk manufacturer for Mrs. Wilson's inaugural gown. None of this material was ever sold by the yard, as only enough was made for Mrs. Wilson's use, the cards which made the design being immediately destroyed. "The first lady in the land," therefore, had the distinction of wearing an exclusive gown that could never be duplicated by any other woman.

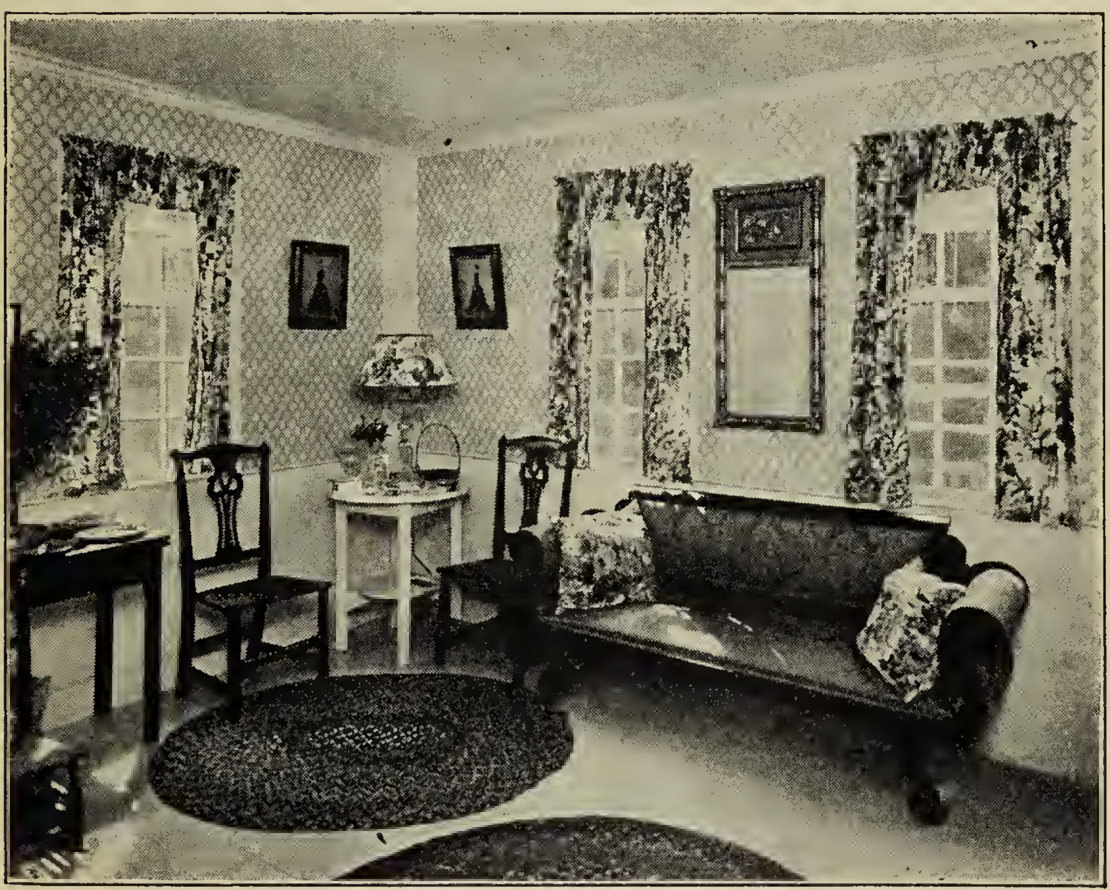
Another American silk firm commemorated the decoration of Marshal Foch in 1918 by a special silk which bore on its selvage "Dedicated to Marshal Foch." The design was an original combination of the seven stars and four rows of oak leaves,—the emblems which Marshal Foch as Generalissimo of the Allied Armies in France was the only man permitted to wear. This material was produced in quantities and sold in our retail stores, but the unique design always marked it as a special compliment to Marshal Foch.

4. *Varieties to supply demands now obsolete.* It is interesting to trace the history of demands that are now almost

or entirely obsolete. Take, for instance, some of the older cloths which, because of the demands of those times, were for years the staple materials of our ancestors. Among them are linsey-woolsey, red flannel, Turkey red, and haircloth. Each, in its time, seemed very necessary to the comfort or pleasure of its users; but as the habits of people changed, as their mode of living became different, the demand for these materials diminished, and requests for them are now seldom heard. Linsey-woolsey, that was so universally worn and so heartily disliked by the children of Colonial times, was suited to the hard work and few luxuries of those pioneer days. With the increase of wealth and leisure more attractive materials served every purpose. Red flannel, so long a picturesque material for the shirts of firemen and engineers and for the voluminous petticoats of our Colonial grandmothers, has been almost entirely replaced for the men by knitted underwear, which is more sanitary, and flannel shirts in which the color is more subdued. In these times of heated houses and greatly improved style of undergarments, women no longer require the warm, bulky skirts of those early days. Before the introduction of coal-tar dyes there were only a few brightly colored cotton materials whose color was guaranteed to be fast. Turkey red was one of these; hence its popularity. With the present variety of wonderful hues that can be found in cotton materials which will keep their color as long as the cloth lasts, our need for Turkey red is very slight. The stiff black haircloth of Colonial times was suited to the austere days of that period when the "best room," where the haircloth furniture was found, was used only on great occasions. To relax comfortably in the presence of guests was not considered good manners, and the stiff haircloth of the chairs and davenport assisted one in keeping to the upright, formal position demanded by the social standards of those days. Since then people have grown to see that dignity may accom-

pany relaxation, and our haircloth furniture has been replaced by velours and tapestries.

5. *Varieties for emergency needs.* When an emergency demand appears in the textile world, it is interesting to watch the ingenuity and efficiency of cloth manufacturers as they



THE STIFF, FORMAL APPEARANCE OF A COLONIAL HOME

spring to the fulfillment of the need. Marked illustrations of this ability on the part of textile makers were shown in the World War period, when a sudden and tremendous increase of war materials was required. Mills that had hitherto manufactured woolen or worsted dress goods and suitings now turned out O. D. flannel or army blankets; carpet mills turned to making cotton webbing; and even silk and lace mills changed to making duck, denim, gauze, and sheeting. In other words, mills that had been built to manufacture only

civilian materials were now adapted to produce military fabrics of quite a different kind. One large woolen company that operated fifty-seven mills converted 90 per cent of its equipment into making army blankets and fabrics. At this time, also, other demands in the textile field sprang up with great insistence. A strong combustible material was required to hold the powder for big guns, and the ingenuity of our textile experts produced cartridge silk. This was made from silk noils which had formerly been used in our spun-silk fabrics but were now made up into a most satisfactory material for holding powder. With the tremendous increase in the use of airplanes came a corresponding increase in the demand for textile materials for the wings, and after much experimentation a kind of mercerized cotton was produced which proved itself equal to the task.

As the abnormal drain upon the normal or decreased supply of raw textile materials of the world continued, the new demand often required the use of a substitute fiber from which the fabric could be evolved. When the supply of flax for linen decreased, because of the devastation of the flax-growing areas, hemp, jute, and mercerized cotton were adapted to take its place. Mercerized-cotton damasks took the place of linen damasks during that war period, and linen towels and handkerchiefs were replaced by those of mercerized cotton. With the great reduction of our wool supply much more coarse wool, remanufactured wool, and cotton entered our wool fabrics than ever before. These substitutes were even demanded during the war for army and navy materials, some specifications calling for 35 per cent of remanufactured wool in blankets and overcoating cloths for our soldiers.

In some of the European countries (Germany, for instance), where the supply of all kinds of raw materials for making cloth was becoming alarmingly exhausted, the manufacture of clothing out of paper was carried on to some extent.

New demands for textile fabrics are constantly arising in civil life. One of the most insistent is the demand for cotton cord or fabric in automobile tires. With the almost unprecedented growth in the use of motor vehicles both for pleasure and for practical purposes has come a demand for a tire that will live under the strain of speed and weight. The world of cloth has combined with the world of rubber in the production of this much-needed article.

The bewildering maze of fabrics. Thus we find ourselves at the present time bewildered by the many different kinds of cloth. If we were obliged to give the names of the entire list of materials, we should surely be lost. We have cloths that are thick and those that are thin, heavy and light, rough and smooth, stiff and limp, coarse and fine, crinkled and straight, figured and plain, wide and narrow, double-faced and single-faced, pile-surfaced and sheared-surfaced, knitted and woven, white and colored, enduring and perishable. As we contemplate this amazing array of fabrics we may well say to ourselves, "How is it possible for an amateur with little cloth experience to obtain in a limited time sufficient textile information to be of practical use in selecting the most suitable materials for definite purposes?"

To suggest some simple ways of learning the intrinsic characteristics of textile materials, so that their natural reactions under different conditions may be anticipated, is the purpose of the following chapters.

QUESTIONS AND ASSIGNMENTS

1. Watch the advertisements in your daily paper for a week and list all the names of cloth mentioned.

2. Bring samples of five staple fabrics and three style fabrics. Give the width, price, and uses of these fabrics. When did the style fabrics first appear in your city? What is the prospect of their permanent place among cloths? Why?

3. Give the names of the materials in the clothing you are now wearing.

4. What is lingerie? How is the word *lingerie* pronounced? What materials are used for lingerie?

5. Find in one of the magazines or trade papers the name of a new kind of cloth that is being advertised. If possible, get a sample of the cloth. Watch for its growth in popularity.

6. Collect woven labels. Find out, if you can, where they were made, by what firm they are used, and any other interesting information about them.

7. Give the origin of the names *calico*, *damask*, *khaki*.

8. Name five drapery fabrics. Which one is most popular at the present time?

9. Get from older friends the names of materials which they have known or used but which are now seldom if ever found. Find out, if you can, the reason for their decline.

10. Name a cloth characterized by each adjective in the last paragraph of the chapter.

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CHAPTER II

BASIC DIFFERENCES IN FABRICS

In attempting to clarify this apparently hopeless confusion of fabrics let us examine some of the articles in common use and discover the ways in which the cloth in one of them differs from that in any other. Take, for instance, first, a linen-damask napkin; second, a colored silk stocking; third, a plaid wool sports skirt; fourth, a tweed cap; fifth, a percale apron (with a colored figure on a white ground). Note, in order of conspicuousness, the differences between the materials.

Color a cause of difference. Throw these articles on the desk or table before you and stand off a few feet as you look at them. What is the most noticeable difference between these materials as you see them a short distance away? "They are of different colors," you say at once, and is it not true that color is always the first characteristic noticed among fabrics?

As we study these cloths from the standpoint of color, we find that the napkin is white but is a different white from unbleached muslin. Hundreds of varieties of white are found in the world about us, and manufacturers produce many varieties of white in cloth by extracting the natural coloring matter from the substance of which it is made,—bleaching, it is called.

The stocking is of one plain color, each stitch in the material being the same color as all the other stitches. The stocking was probably dipped in dye after being made from

uncolored yarns. Materials of plain colors dyed in this way are called "piece-dyed."

The plaid sports skirt contains several colors, which are the same on both sides of the cloth. By looking at the material more closely we see that the plaid effect is produced by the different colored threads, or yarns,[1] of which the cloth is made, and we conclude that the yarns were colored before this fabric was woven. The material in the skirt is called "yarn-dyed," this method of coloring being very often employed in cloth manufacture. The historic plaids, or tartans, that form the picturesque garb of the Scottish Highlanders are striking examples of yarn-dyed materials.

In the tweed cap the yarns themselves seem to be made of little bunches of material of different colors. How can this effect be produced? Yarns are made, as we shall learn later, of masses of tiny hairlike fibers called raw material. For certain color effects in cloth these fibers are dyed before the yarn is made. This is called "stock-dyeing" and allows the making of the multicolored yarns so attractive in tweeds.

When we examine the color of the percale apron, we find an effect different from all the others. Figures in color are found on only one side of the cloth, proving that neither the raw material, the yarn, nor the goods was dipped in dye. Color was stamped on the face of the percale. This process is called "printing." There is a multitude of materials to which the color is applied by printing, the patterns and color combinations in many cases being truly marvelous.

Construction a cause of difference. As these articles still lie on the table let us examine them more closely, this time disregarding the color. What difference do you now detect between these materials? You doubtless discover at once that they are made, or constructed, differently. The silk

[1] By *yarns* is meant the continuous strands of twisted materials of which cloth is made. We, perhaps, have always called them threads.

stocking is knitted, and the cloth in all the other articles is woven. Knitting and weaving are the two chief ways of making cloth, but among both knitted and woven goods there are obvious differences in appearance. For instance, compare the material in a "drop stitch" stocking or a knitted necktie with the fabric in this stocking and you will have some idea of the variations that are possible in knitting. The looping, knotting, and interlacing of threads in lace making are an adaptation of knitting. Think what a variety there is among materials of lacy structure!

A SCOTTISH HIGHLANDER IN STREET ATTIRE

Among woven fabrics there is an even greater opportunity for variation in structure. When the napkin was woven, the yarns crossed in such a way as to make an elaborate design which will always remain. In the making of the skirt material the crossing of the yarns produced fine diagonal lines running from the upper right-hand to the lower left-hand corner of the goods, while in the tweed cap and the percale

apron the cross yarns simply pass in and out regularly among the lengthwise yarns, making a compact cloth with neither pattern nor lined effect.

Raw material a cause of difference. Take the articles in your hands and feel of them. Crush them, rub them against your cheek, and note the difference in the feel and behavior of these fabrics. The stocking is "soft as silk," which makes it a delight to touch and handle. The napkin is smooth but not soft like the stocking. The percale apron feels stiff and less smooth than the napkin, while the plaid skirt and tweed cap seem almost harsh when compared with the others. There is a sheen about the stocking and the napkin which is not found on the other articles. If our sense of feeling is fine enough to detect slight differences in temperature, the napkin will feel cool and the skirt and cap warm to the touch; and it is very apparent that the napkin and the apron wrinkle much more easily than the stocking, cap, or skirt. There are many more differences which can be discovered in the behavior of these materials, but this simple study shows that they have very different characteristics, which we know from experience will remain as long as the cloth lasts. This permanent difference in the feel and behavior of these fabrics is due to the fact that each of them is made from a raw material which is quite unlike that in any of the others. (In the cap and skirt the raw material is similar.)

Finish a cause of difference. The finishing processes, which are the last treatments to which textile materials are subjected before being offered to the public, are important in bringing about changes in their appearance. Two cloths may be identical in color, construction, and raw material (like certain grades of batiste and nainsook), and yet, because of the final treatments, or finish, may differ in name and purpose. The finishing processes may cause only a slight dif-

ference, as in the two fabrics mentioned, or they may produce such a change as to make the two cloths seem quite unrelated. Compare batiste with paper cambric, nainsook with plissé, outing flannel with a soft, plain muslin, and the effect of the finishing operations is at once apparent.

We see, therefore, that in many cases fabrics which at first glance appear very different may be closely related. The color chemist has a wide scope for his talent in the field of textiles, and our great variety of colored fabrics is the result of his endeavors. The cloth designer finds limitless opportunities for the creation of new patterns, a slight variation in the interlacing of yarns producing a change in the appearance of the material. The variety of natural textile materials is relatively small, but man's ingenuity in adapting them to his purposes seems marvelous. He is able to change the character of some and, by artificial means, to imitate others. The cloth finisher produces such wonderful changes in fabrics as to completely transform their original appearance. If we should take at random any two pieces of cloth that seem very unlike, and search for the causes of their dissimilarity, we should find that the differences were brought about by one or more of the four means described,—the method of coloring, the manner of constructing, the nature of the raw material, and the character of the finish. When we appreciate that all the variations in our world of cloth can be reduced to a few basic differences, the study of our maze of fabrics becomes at once both simple and interesting.

QUESTIONS AND ASSIGNMENTS

1. Bring one sample each of piece-dyed, yarn-dyed, stock-dyed, and printed materials.

2. Which method of coloring produces the greatest variety of fabrics? Which, do you think, should produce the most permanent coloring?

3. Bring a sample of cloth showing a Scottish tartan. To what clan does this plaid belong? (If impossible to find the pattern in cloth, copy in colors one of the designs in the book on tartans.)

4. Is the material in your dress (or suit) knitted or woven? Name five articles of wearing apparel that are usually made from knitted fabrics.

5. Collect as many samples of tweed as you can. Count the number of colors used in each. Get information on tweed from various sources and give some interesting facts concerning this cloth.

6. How many kinds of raw material are named in this chapter? Tabulate characteristics of each kind.

7. For what purposes are wool materials used most frequently? linens? Why?

8. What articles of clothing are always made from knitted fabrics? from woven fabrics?

9. What raw materials are employed in the garments you are now wearing?

10. Name three fabrics invariably made from cotton. Name as many as you can that are invariably made from each of the other fibers (silk, wool, linen). Why are these lists more difficult to make than the one of cotton?

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See page 369.

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CHAPTER III

THE MAKING OF CLOTH: WEAVES AND THE WEAVING PROCESS

Uses of fabrics determined by their character. Let us study some of our common articles of clothing and house furnishings to see why certain kinds of cloth are suitable for some purposes and entirely unsuitable for others. For instance: Why is this Turkish towel good for drying the skin after a bath, while it would be undesirable as a handkerchief? Why is this piece of marquisette very attractive for curtains and not at all suitable for sheets and pillowcases? Why do we enjoy this beautiful damask (samples should be of cotton) for our tablecloth when we should refuse to wear it in a blouse or a petticoat? Why should we buy white cotton gabardine for a sports skirt when we should buy Indian Head or butcher's linen, instead of gabardine, for our large white kitchen apron? There are many similar questions that could be asked about our everyday textile materials, showing that people universally buy a certain kind of cloth for one purpose and a different kind for another purpose.

What is the chief reason for this discrimination in the uses of the fabrics that we have mentioned? It is not because of the style element, for most of the cloths named are old, staple materials whose uses have not changed for years. It is not because of the color factor, for these materials are all white. It is not because of the kind of raw material of which they are made, for these fabrics are all of cotton. It is not because of the price, for there are wide ranges in the price

of each of these materials. In what way, then, do these cloths so differ as to be thus specialized in their uses? By closely inspecting the materials mentioned we shall find the answer to our question.

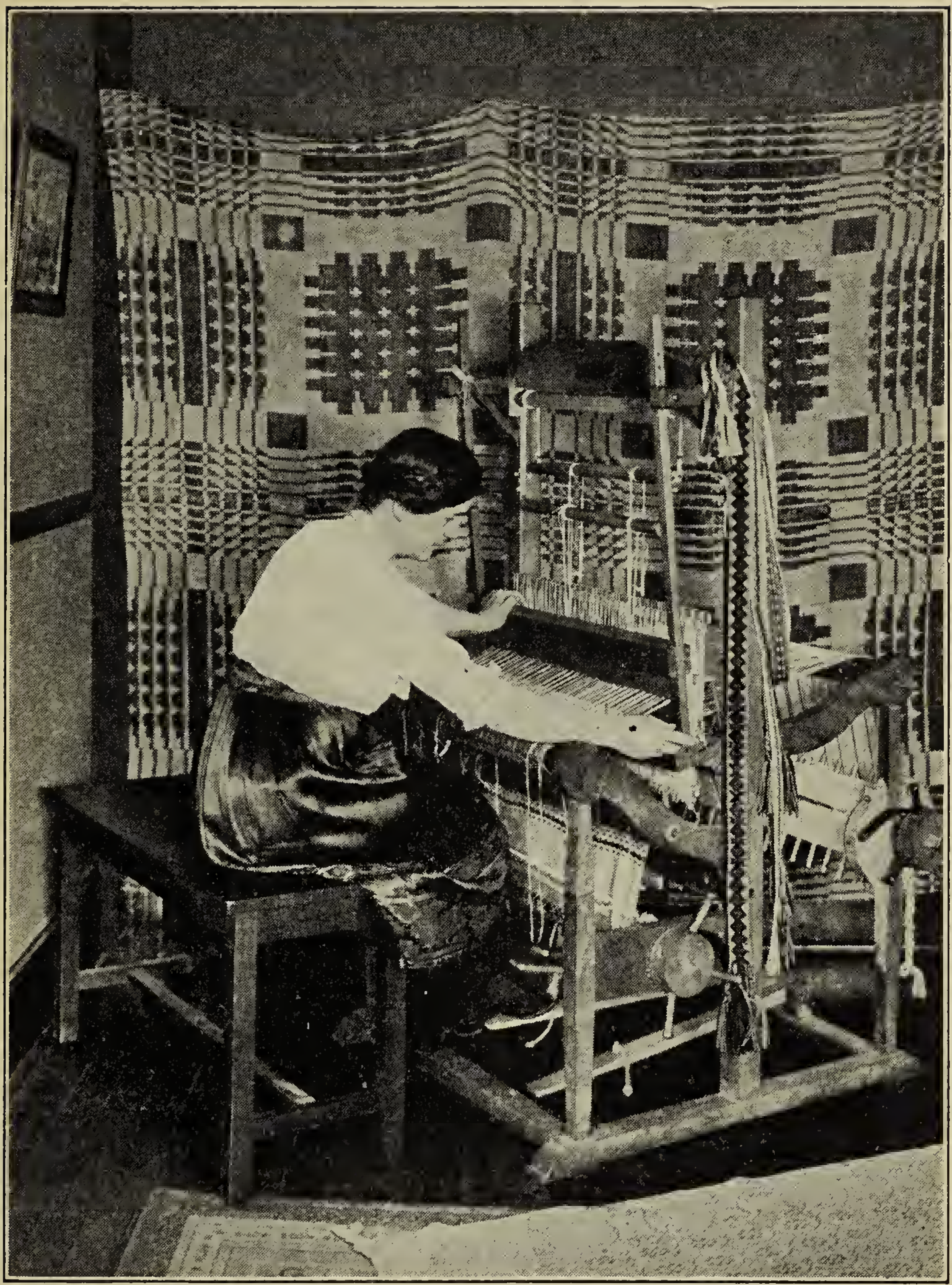
Variations in construction of cloth. Both sides of a Turkish towel are covered with loops. These loops not only absorb the water but they cause a friction when the towel is used which makes the skin glow and tingle. This sensation is very delightful after a bath but is not the effect we wish produced by a handkerchief.

In curtain marquisette the yarns are far apart, making relatively large spaces in the cloth. A closer examination of the material shows that these yarns are twisted around each other so that they will not slip and fill the spaces. This open characteristic is highly desirable in curtains, but in bed linen it would be neither comfortable nor protective.

The tablecloth has a beautiful design caused by the special interlacing of its yarns. In some parts of the figure yarns that run in one direction are seen distinctly, while in other sections those that run at right angles to these show just as plainly. If we try with a pin to lift any of the yarns, we find that at times they float[1] quite a little distance before being caught down by a cross yarn; in other cases a yarn is crossed so frequently that we can hardly get the pin point under it; and we discover that the pattern is caused by this varied exposure of the yarns. When damask is spread out in a horizontal position, so that its full surface can reflect the light, the beauty of the complete pattern is shown, making this material a joy to use for the table. If used for wearing apparel, the entire design could not appear, and the vertical position would much decrease the beauty of the material.

The white gabardine is very attractive, with fine diagonal ridges running across its face. The back of the cloth is not

[1] *Float* means to pass over several successive yarns.



A HAND LOOM ON WHICH ARTISTIC WEAVING CAN BE DONE

Courtesy of Mary M. Atwater

the same, however, so care must be taken to make the garment right side out. For a white kitchen apron, goods having no "right and wrong" is preferable. The yarns in gabardine lie very close together, and the stripes or ridges soil rather easily. Plain material that is easier to wash and less easy to soil than that with ridges best answers the requirements of a work apron.

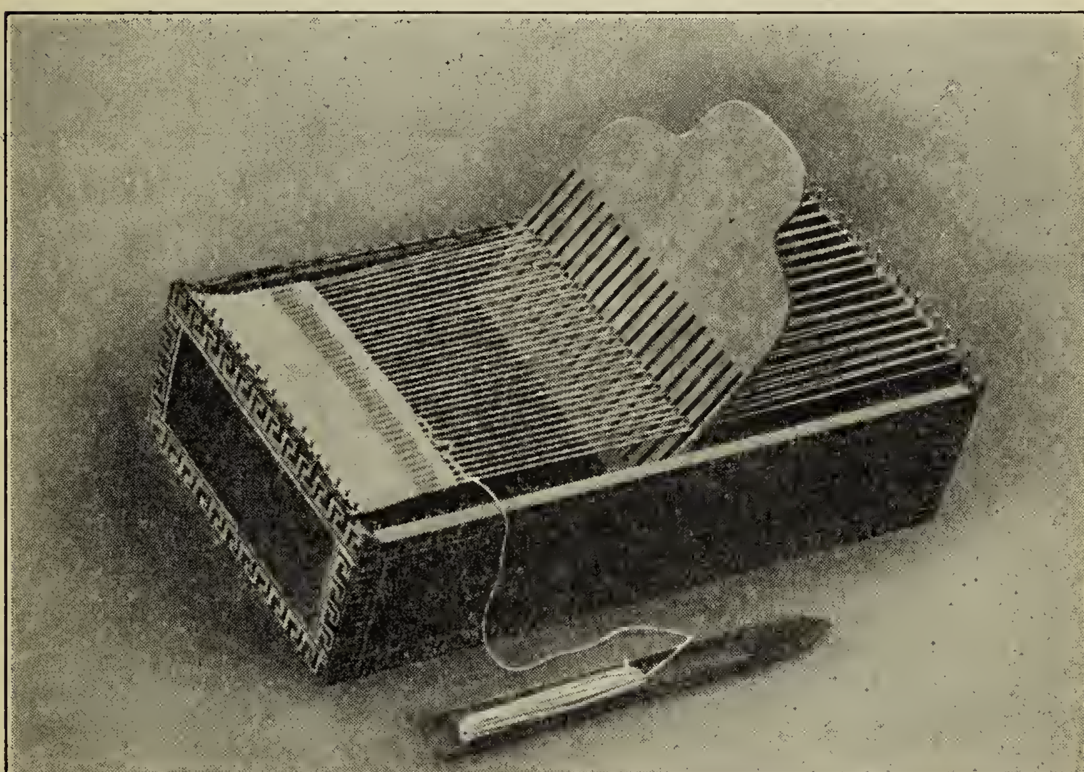
Many more illustrations could be drawn from our common fabrics, but these few examples show that the method of construction is the factor which determines the use of materials very similar in other characteristics.

All cloth either woven or knitted from yarns. We notice that all the fabrics that we have examined are made of yarns closely and firmly laced together. Nearly all the cloth in the world, regardless of its nature, color, or use, is made by a process of interlacing, looping, or tying yarns together in such a way as to form a compact material. *Weaving,* the method by which woven cloth is made, consists of interlacing one set of many yarns by one or more continuous strands of yarn. Knitted materials are made by *knitting,* which consists of constructing a fabric by continuously interlooping one or more strands of yarn. These two processes, weaving and knitting, are the general methods of constructing cloth. Many variations of the simple fundamental processes are made, however, and these variations greatly increase and control the uses of fabrics.

The loom, a machine for weaving cloth. A loom is a machine on which woven cloth is made. Its principle is to hold firmly in a horizontal position a set of yarns, across which the shuttle, an implement carrying a continuous strand of yarn, flies back and forth, leaving its trail over some and under other yarns as has been planned by the design of the cloth.

Warp and filling. Let us lay a two-inch piece of surgical gauze on our desk with the set of yarns that seems most uni-

form in size and tension parallel with the edge of the desk. (It is usually difficult to decide in a piece of cloth having no finished edge, or selvage, which set of yarns is more uniform in size and tension. In this particular case, however, a doubtful selection will not injure the principle to be illustrated.) These are the *warp* yarns, which were stretched horizontally



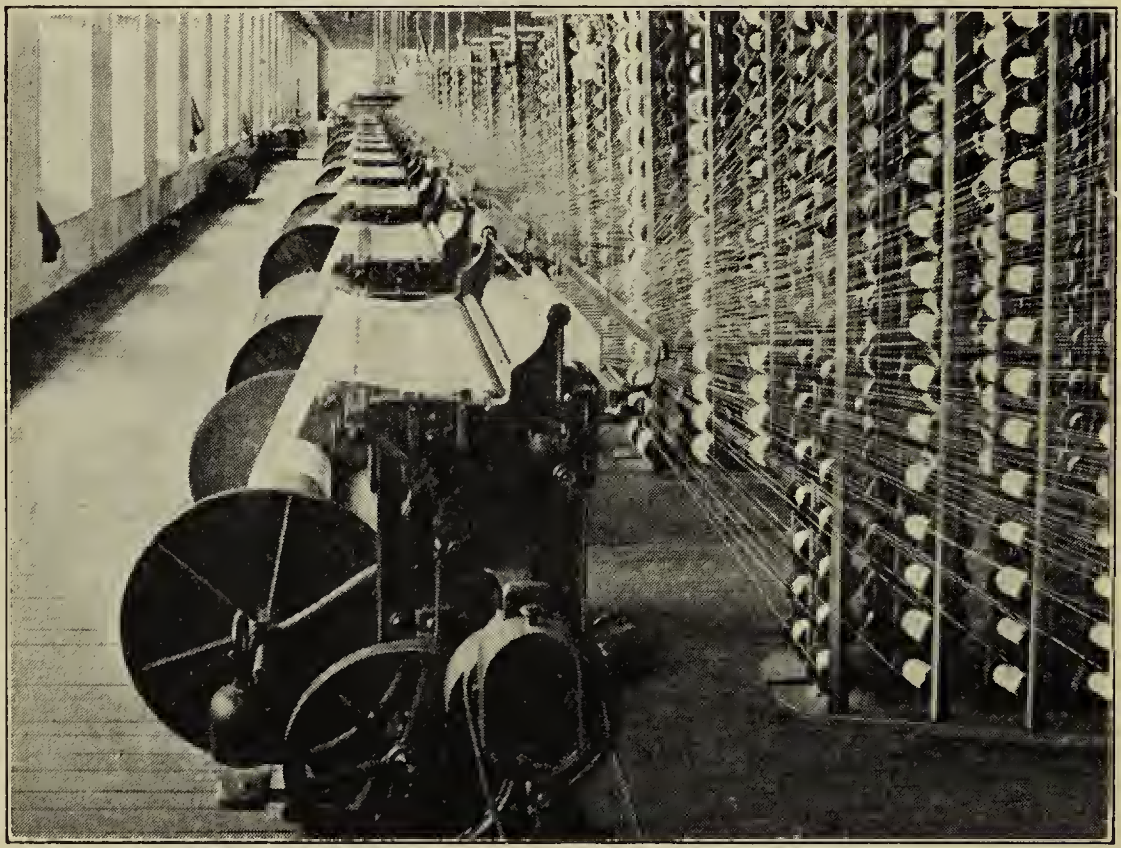
A HOMEMADE CIGAR-BOX LOOM

over the loom. In the factory they are called warp ends or *ends,* a term which is often heard in the stores. Those running at right angles to the warp yarns are the *filling,* which was left by the shuttle as it flew back and forth across the warp. The old names for filling are *woof* and *weft,* these terms being found in the Bible (Leviticus xiii, 47–59). The mill name for filling yarns is *picks.*

Essential parts of a loom. A loom may be either a very simple affair, such as can easily be made from a cigar box, or it may be a most complicated machine which takes months to

set up; it may be large or small; it may be operated by hand or by some other power; but in all looms there must be certain essential parts to carry out the principles of weaving.

1. *Warp beam.* In every piece of woven cloth there are many warp yarns, or ends. In fine cotton materials we



© Keystone View Co.

WARP WINDING

can count over 100 ends to an inch. That means that if the cloth is 36 inches wide there would be more than 3600 ends in the warp.

We have it on good authority that there has been found mummy cloth, made in very early times, containing 540 warp ends to an inch. The finest cotton cloth now woven for commercial purposes contains 350 ends to an inch.

A "cut," or bolt, of cloth in the store is usually between 40 and 60 yards long, these pieces being cut from strips that may have been several hundred yards in length when woven.

The warp ends, therefore, must be long enough to make the desired strip of cloth, sometimes measuring from 25,000 to 30,000 yards. These ends, in the number and order in which they are to be used, are wound on a large beam or cylinder, the winding of the warp being a very skillful piece of work. This warp beam is usually at the back of the loom and is to hold the warp.

2. *Cloth beam.* As the cloth is woven it is wound upon the *cloth beam,* which is usually at the front of the loom.

3. *Shuttle.* There must be an implement to hold the filling yarn, and this is called the *shuttle.* In primitive days the shuttle was nothing more nor less than a twig or stick; today a skillfully constructed instrument is used, yet its functions are the same.

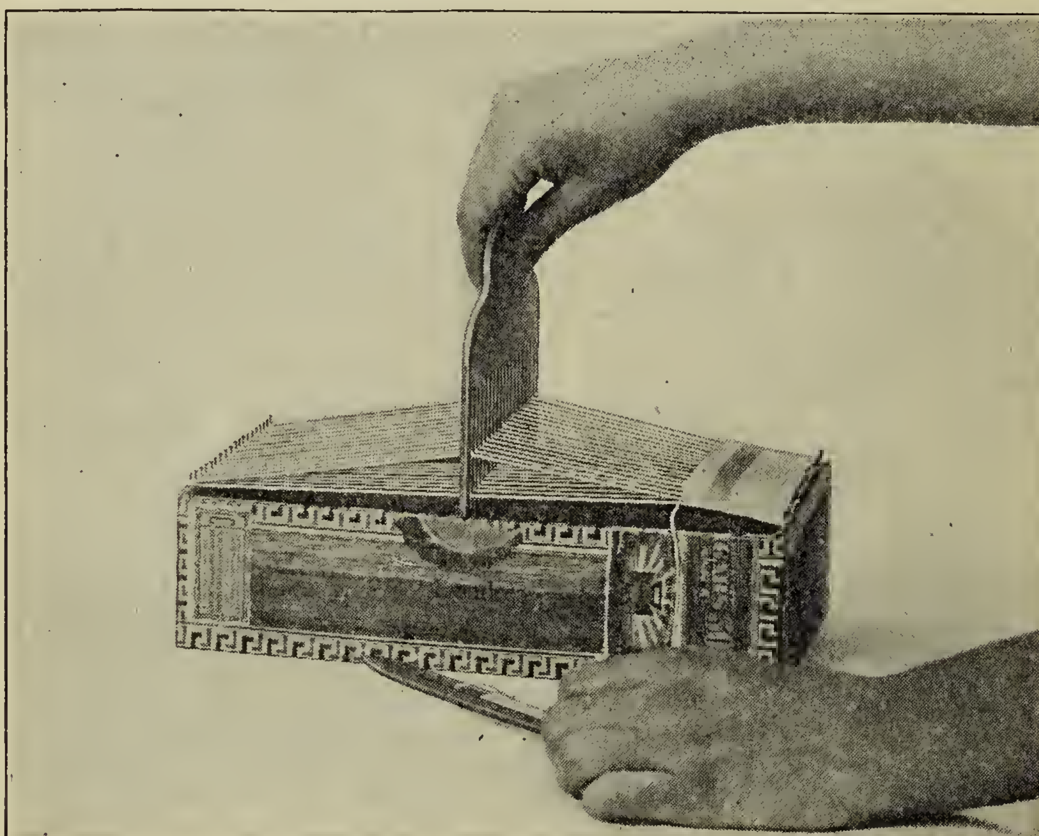
4. *Harness.* Our slight examination of cloth has shown us that the filling yarn passes under certain warp yarns and over others. The shuttle does not laboriously pick its way under and over the yarns all the way across the warp, though this is the way primitive weaving was done. Instead of this slow journey all the warp yarns that the shuttle is to pass under are now automatically lifted at once, making an opening through which it shoots at an almost incredible rate of speed. There must be, therefore, a part of the loom which will control the warp yarns, raising or lowering certain ones in regular order, that the shuttle may pass under or over as determined by the cloth design. This part of the loom is spoken of as the *harness.*

5. *Batten.* To obtain uniformity in the closeness of the weave an instrument is provided to push, or beat, the filling yarns close together. This is called a *batten.*

In some looms of today these parts may be so complicated, and there may be so many other devices and attachments for special work, that it is almost impossible to recognize the essential parts of the mechanism. There are now such highly

perfected automatic looms that they seem to possess almost human intelligence. But in the weaving of all cloth these five parts (the warp beam, cloth beam, shuttle, harness, and batten) must be present in some form and do their work.

Fundamental operations in weaving. As there are only a few parts of the loom essential to the simple weaving of



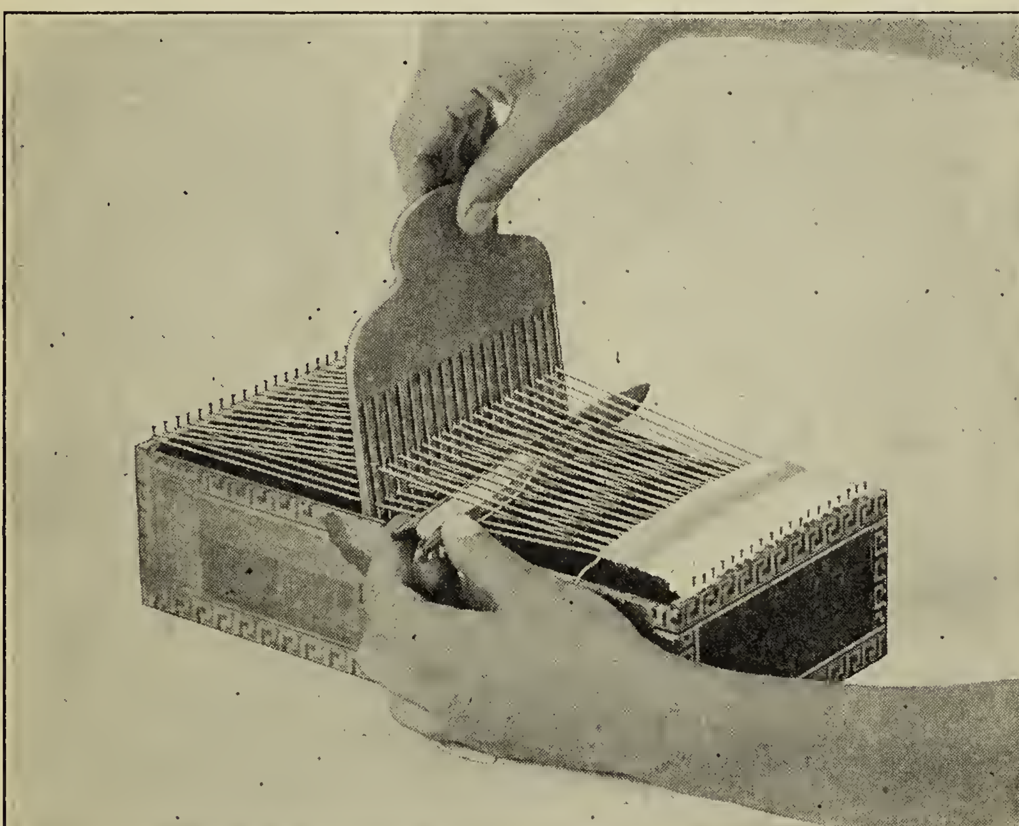
SHEDDING

cloth, so there are only a few fundamental operations necessary for the construction of any kind of woven material.

1. *Shedding.* The first operation of the loom is to open up a space in the warp yarns for the shuttle to pass through, carrying the filling. This is done by means of the harness. The harnesses in looms are raised and lowered by different methods. In simple "cigar box" looms they are operated by hand, in the old-fashioned hand loom they were operated by an attachment worked by the foot, while in the fac-

tory looms they are operated automatically. The making of this path for the shuttle between the warp yarns is called *making a shed* or *shedding*.

2. *Picking*. The next operation is throwing the shuttle through the shed, leaving a trail of yarn which makes one of the picks, or filling yarns. This one passage of the shuttle



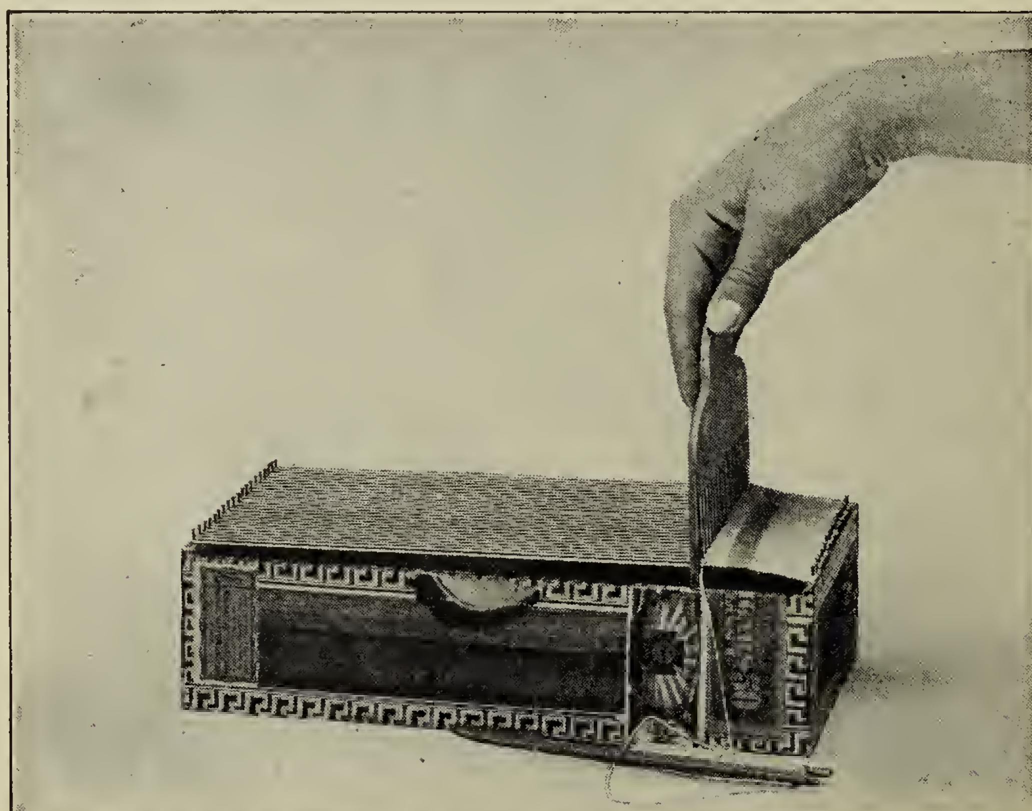
PICKING

is called a *pick*, and the operation is called *picking*. The throwing of the shuttle through the shed was formerly done by hand, but it is now performed automatically.

3. *Battening*. The final step in weaving is to *beat*, or push, close to the others with the batten each filling yarn, or pick, left by the shuttle, and this is called *battening* or *beating*. Battening, which was formerly done by hand, is now done automatically.

For the next pick another harness, holding another series of

warp yarns, is lifted, and the shuttle is thrown back through that shed. The battening of that pick follows, after which another shed is made, followed by picking and battening. The repetition of these three fundamental operations, therefore, is necessary for the construction of any kind of woven cloth.

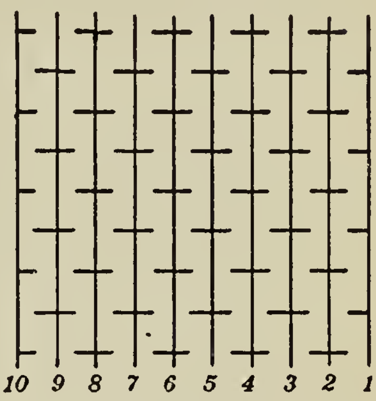


BATTENING

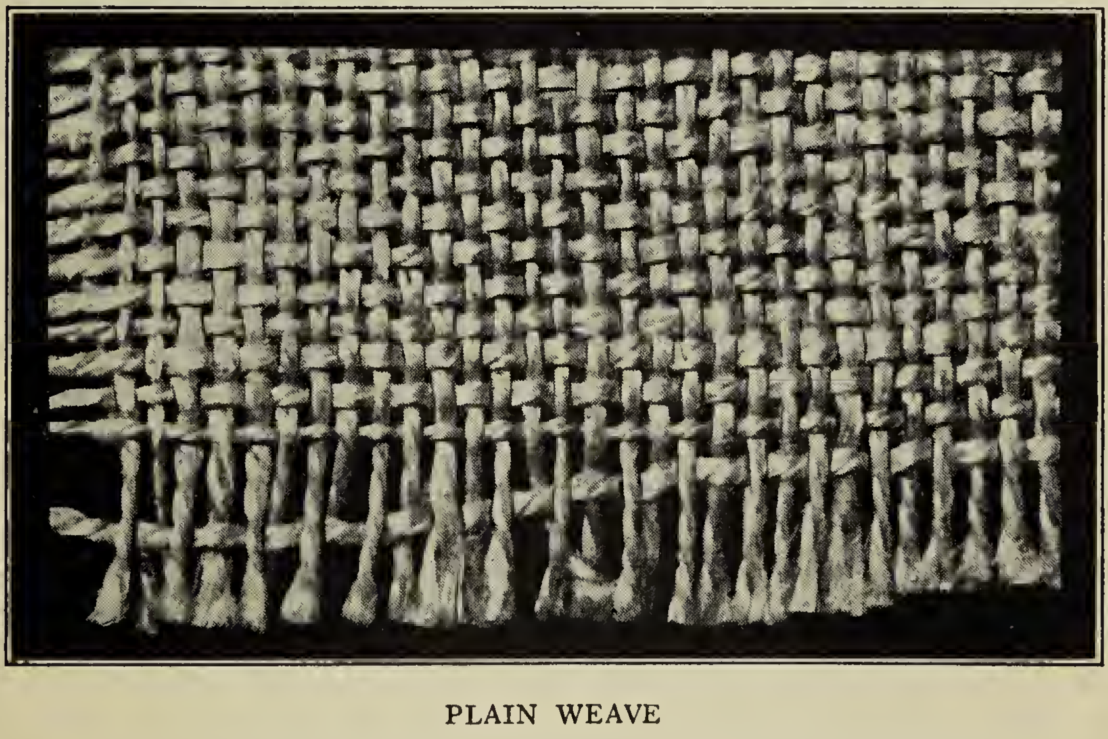
Analysis of weaves. 1. *Plain, simple, or tabby.* In the making of many kinds of cloth only two harnesses are used, each one lifting every other yarn all the way across the warp. If we were to number these warp ends 1, 2, 3, 4, 5, and so on,[1] one harness would lift all the yarns of odd numbers, the shuttle passing under them on one journey across the warp, and the other harness would lift all the yarns of even numbers for the shuttle to pass under on its return trip. This weave is

[1] As the shuttle is usually thrown first from the right edge of the warp through the shed toward the left, we will begin at the right edge and number our warp yarns toward the left.

called the plain, simple, or tabby weave, and the "repeat," or the order in which the filling yarn crosses the warp yarns, is made, as we see, with every alternate pick. If we follow the course of one of the filling yarns in our piece of gauze, we shall see that it passes over one end and under the next, across the warp, alternating the process on its return. This is an example of the plain weave, the making of which is a comparatively simple process, like the darning of a stocking. The value of the product, however, depends upon the skill of the weaver, the quality of material used, and the conditions under which the work is done. All these factors enter into the price that we pay for the cloth we buy; an understanding



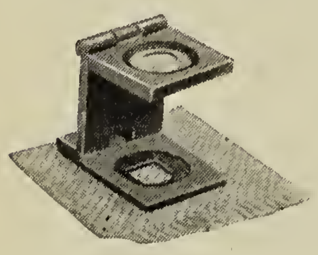
A DIAGRAM OF PLAIN WEAVE, SHOWING THE ORDER IN WHICH THE FILLING PASSES OVER THE WARP YARNS



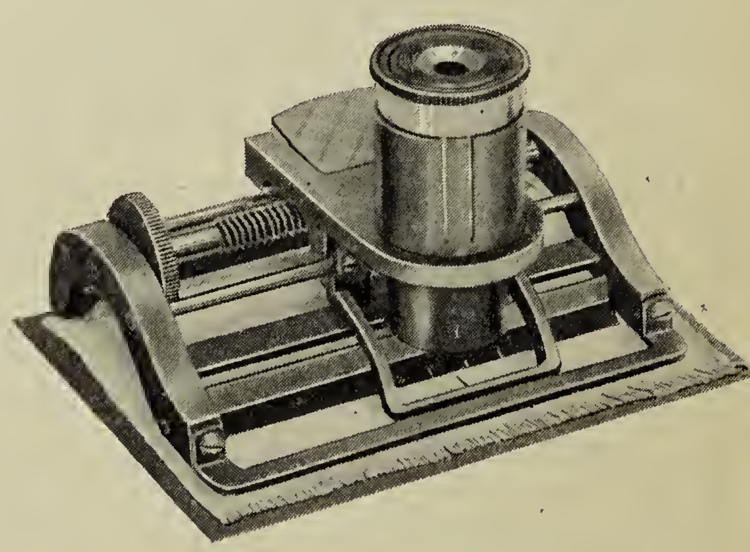
PLAIN WEAVE

of this fact will cause us to be more discriminating in our choice of fabrics and more appreciative of their true worth.

a. The count of cloth. One of the chief factors in the price of cloth is the closeness of its yarns, which cloth manufacturers and buyers speak of as the *count* of the cloth. Count the ends in your piece of gauze. How many are there to an inch of cloth? Count the picks. The count of surgical gauze is about 28 × 24, which means that there are 28 ends and 24 picks to an inch. Before a cloth is woven, a design is always made to show the plan of weaving. Buyers of fine cloths like table linens or fine cottons frequently have a magnifying glass called a weaver's glass, cloth tester, or linen tester, to count the yarns. The size of the field is $\frac{1}{4} \times \frac{1}{4}$ inch. Place a weaver's glass on the gauze and count the ends in $\frac{1}{4}$ inch. Multiply by 4. Do the same with the picks. The most exact instrument for measuring the fineness of cloth is a thread-counting micrometer. Some kinds of cloth have the same number of picks and ends to an inch, making an exactly square mesh; but it is more usually found that there are more warp than filling yarns.

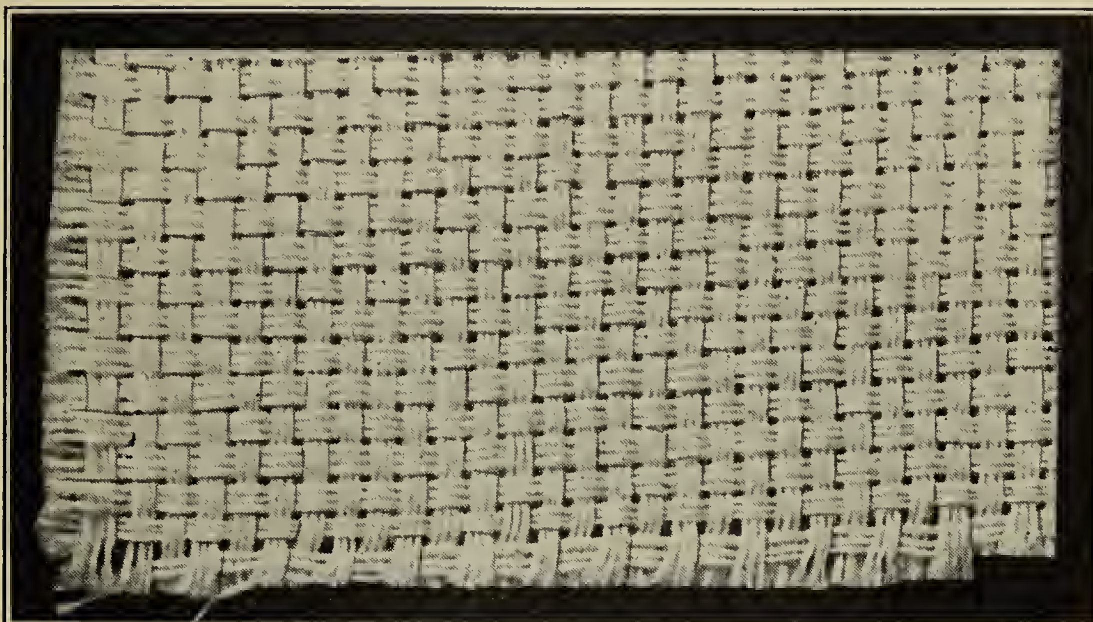


A WEAVER'S GLASS

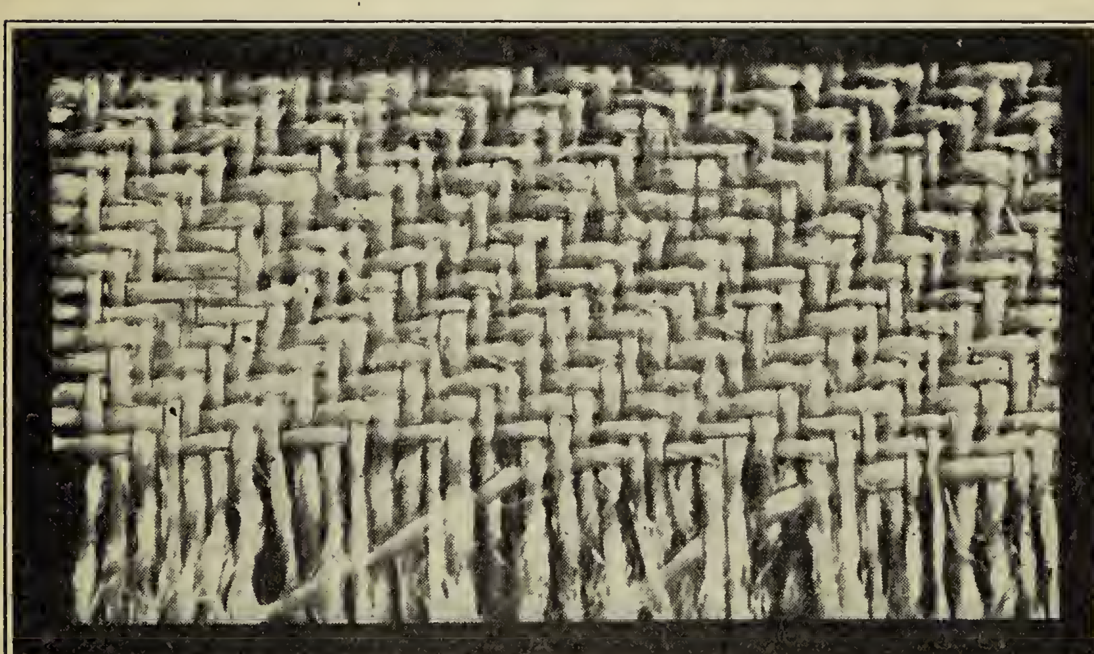


A THREAD-COUNTING MICROMETER

b. Variations of plain weave. In the plain weave two or more yarns are sometimes used as one, both in the warp and in the filling, and we have what is called *basket weave.* Monk's cloth illustrates the basket weave.



BASKET WEAVE



SERGE

Sometimes a heavier yarn or group of yarns is introduced into the warp at intervals, and we have a fabric that is ribbed lengthwise. Striped dimity is produced in this way. When this modification enters into the filling, we have a material ribbed across the cloth, as poplin. When a heavy yarn is introduced into both warp and filling, we have a checked material like crossbar dimity. These are some of the standard variations of the plain weave, and many modifications of these can be found.

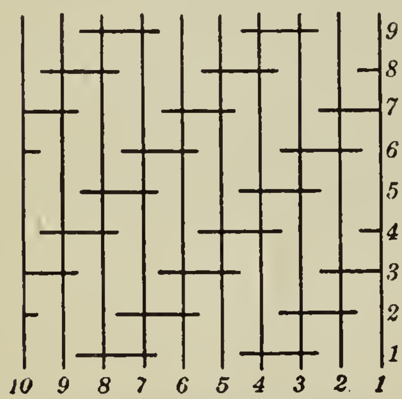


DIAGRAM OF TWILL WEAVE

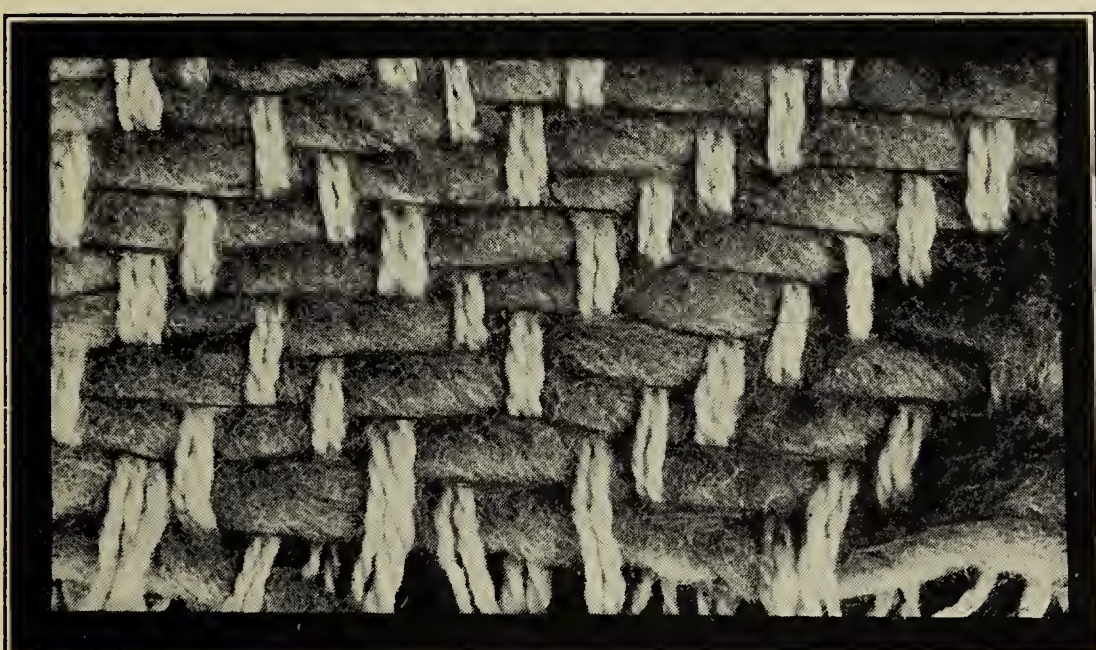
2. *Twill, serge, or diagonal weave.* Is the white gabardine, with its interesting diagonal lines, constructed in this way? How do the two sets of yarns interlace in this cloth? (The simplest form of twill weave is found in coarse wool serge, which is easier to examine.) We discover that the filling yarn in the piece of serge passes regularly over two and under two warp yarns across the cloth. On its return, however, it does not alternate this order, but splits every group as it continues to pass regularly under two and over two warp yarns. In the next row it splits this second group as it keeps up its regular order of progression.

Beginning at the right and numbering the warp yarns to 10, we shall find that for the first row warp yarns Nos. 1 and 2, 5 and 6, and 9 and 10 must have been lifted for the shuttle to pass under; for its return trip Nos. 9 and 8, 5 and 4, and 1 must have been lifted; for the third row the shuttle was thrown under Nos. 3 and 4, 7 and 8; and on its return in the fourth row it passed under Nos. 10, 7 and 6, 3 and 2. The fifth row we find to be a repeat of the first, the following picks continuing in the order described.

Thus we see that in order to make cloth having a regular diagonal weave four different series of warp yarns must be

lifted and four harnesses must be used. This weave is called twill, serge, or diagonal weave. On the face of the cloth the diagonal lines run from the upper right-hand to the lower left-hand corner, making a 45° angle. On the back of the cloth the diagonal lines run in the *opposite* direction.

a. Variations. Twill weave is the basis of numberless variations and modifications. The filling yarn may pass

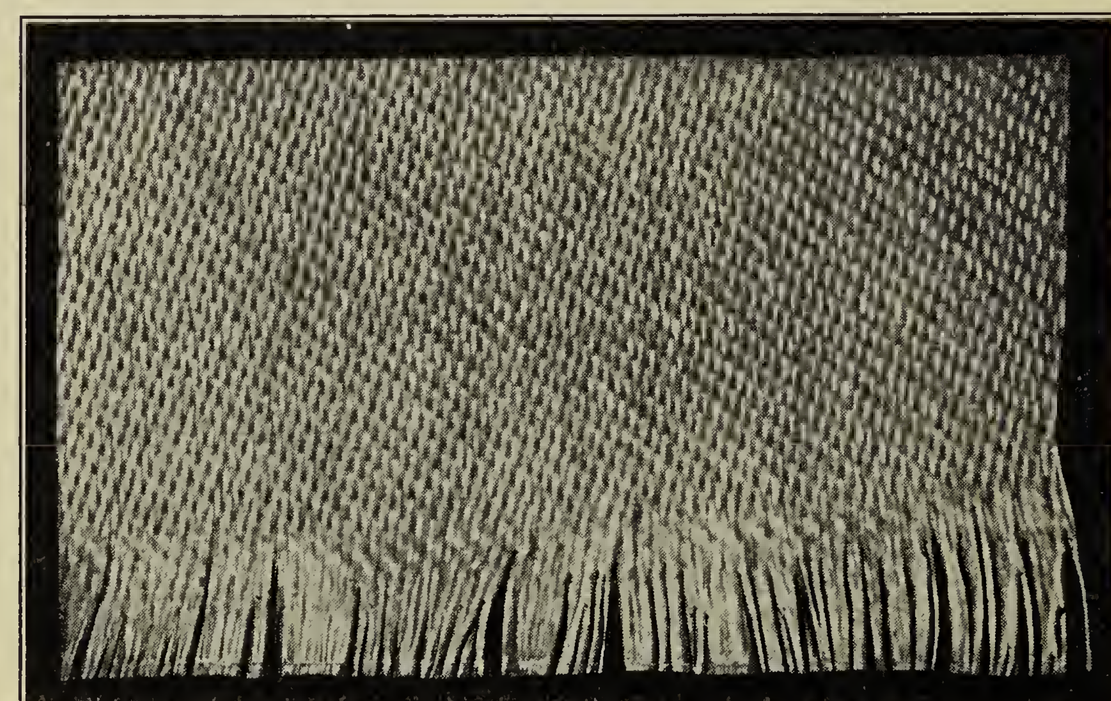


HERRINGBONE WEAVE

over a different grouping from the regular 2 and 2 of serge, giving a steeper or less steep effect to the diagonal line, as is found in gabardine and cashmere. It may follow a different order of splitting the groups, producing a twill in the opposite direction, as we find in denim. It may pass over a large bunch of warp yarns each time, giving a heavy ribbed effect, as in whipcord, or it may be worked out with a double row of twill, as is found in tricotine. It may change the direction of the twill at intervals, giving a pointed, or herringbone, effect, or it may introduce some other design in weaving and produce a broken twill effect. When we begin to notice the

kinds of weaves used in the cloths seen every day, we are amazed at the many variations of the two standard weaves already named.

3. *Satin.* Pass your hand down the length and then across a satin coat lining (for study, use samples of cotton-backed satin). We find upon examination that much of the warp is exposed on the right side, or face, of the cloth, and very



SATIN

little of the filling. Look at the back of the cloth. Little of the warp and much of the filling are exposed on the back. In analyzing this material we find that the filling passes several times under each individual warp yarn, thus leaving it free for some distance and "throwing it to the face," as it is called. This principle is reversed in sateen, the face of which, as we can tell by passing our hand across it, is made almost entirely of filling. Yarns exposed in this way, whether of warp or filling, are called *floats*. The length of the floats depends upon the number of times yarns of the other set pass under them.

Let us number the warp yarns in this piece of satin and see how the filling yarns intersect them.

First row: Nos. 1 2 3 4, 6 7 8 9, 11 12 are lifted.
Second row: Nos. 11 10 9 8, 6 5 4 3, 1 are lifted.
Third row: Nos. 1 2 3, 5 6 7 8, 10 11 12 are lifted.
Fourth row: Nos. 12, 10 9 8 7, 5 4 3 2 are lifted.
Fifth row: Nos. 1 2, 4 5 6 7, 9 10 11 12 are lifted.
Sixth row: Begins the repeat.

This weave requires five harnesses and is called the 5-shaft satin weave. It is the simplest form of the satin weave and is found in many of our light-weight satins. In the 5-shaft satin weave only four rows of filling pass under each warp yarn, but in some forms of the satin weave a warp yarn may float over seven, nine, or even eleven filling yarns.

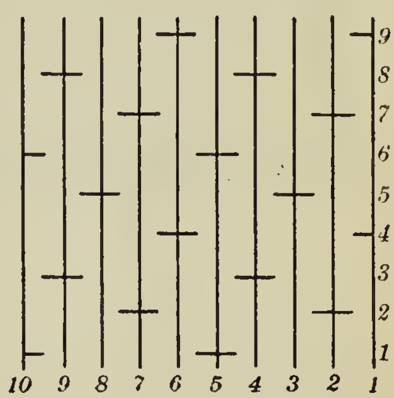
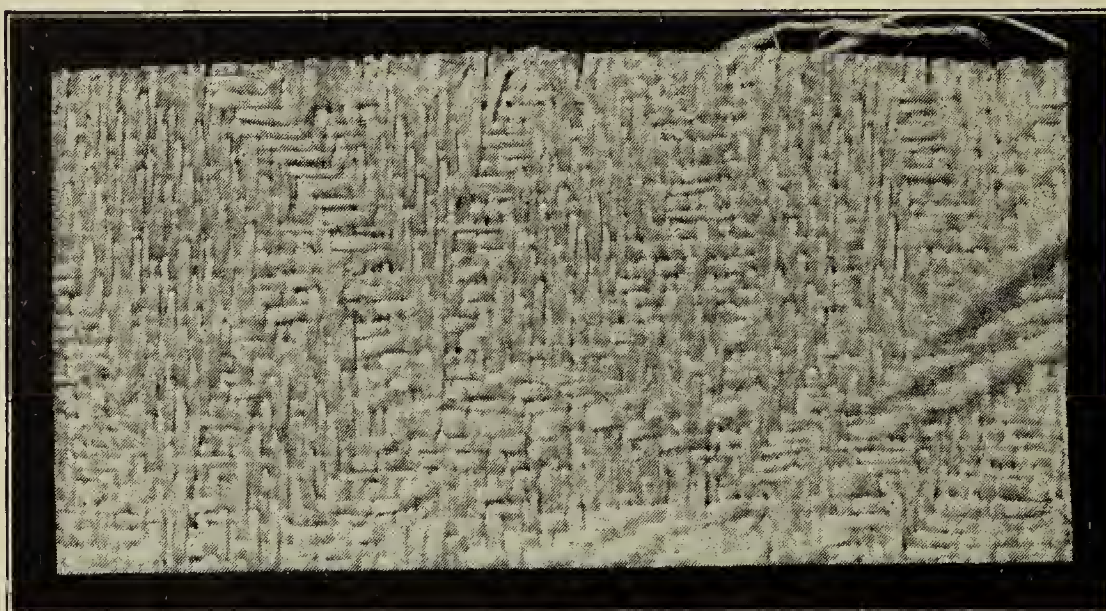


DIAGRAM OF SATIN WEAVE

These three weaves (the simple, plain, or tabby; the twill, serge, or diagonal; and the satin), with their many modifications and variations, are the weaves most frequently found in textile materials. They are called the three standard weaves and are here named in the order of their ease of manufacture and their frequency of use in fabrics.

4. *Damask.* Is the piece of damask, with its elaborate pattern, woven like any of the cloths already studied? If we attempt to follow the path of a filling yarn in this material, we soon become hopelessly lost on our way. There seems to be no regularity in the number of yarns the filling passes under and over, and it is quite impossible for us to find the place where the pattern begins to be repeated. What a multitude of harnesses it must take to lift the many different series of warp yarns which this pattern requires! It

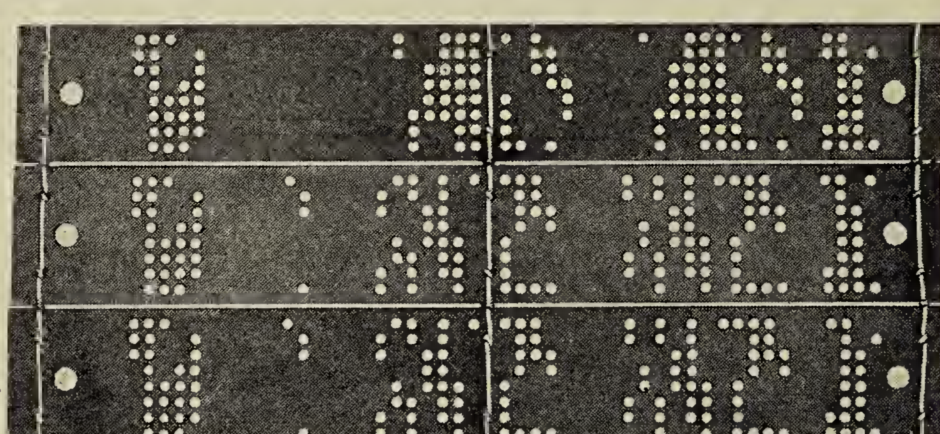
would, indeed, take so many harnesses that a loom so equipped would be quite impracticable to use. This cloth



DAMASK

is woven on a Jacquard loom, which is one of the most wonderful machines in textile manufacture.

The Jacquard loom. The Jacquard loom was invented by a Frenchman, Joseph Marie Jacquard, in 1801. It carries



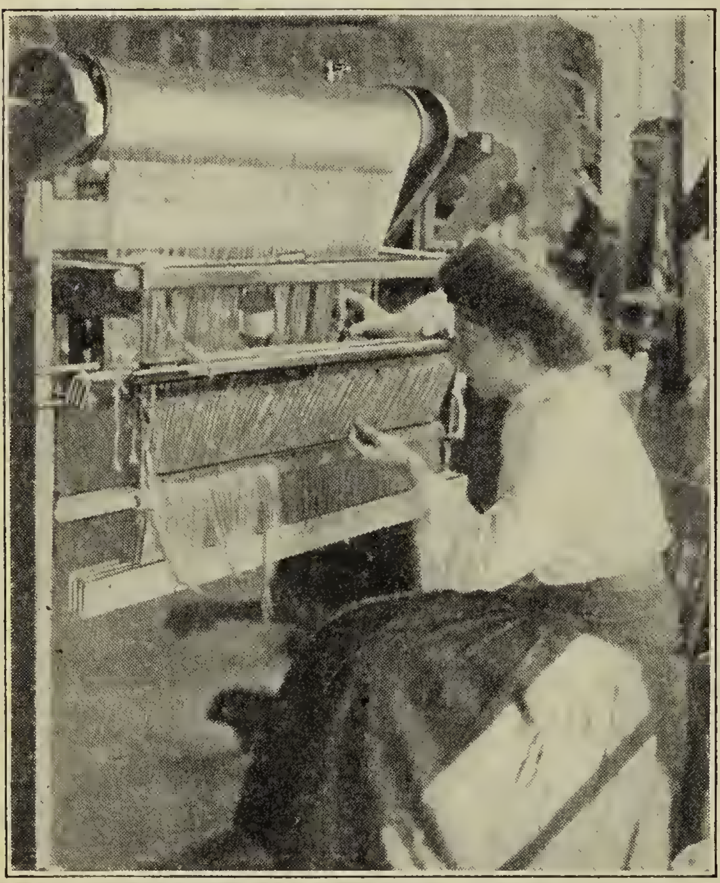
JACQUARD CARDS

out the principle of shedding by an elaborately prepared apparatus which allows each warp yarn to be controlled separately, being lifted only as needed. The Jacquard loom

is much too complicated a machine to describe in a few words, so we shall try to give only an idea of the complexity of the Jacquard system of weaving. After the design of the cloth is made, each pick is worked out on cross-section paper, as has been shown in the other three weaves. Instead of being lifted by harnesses the warp yarns are controlled by a series of prepared cards. A card is punched with as many holes as there are warp yarns for the shuttle to pass under on a single trip across the cloth; for the next pick another card is prepared, showing by its holes the number and order of warp yarns to be lifted; for the third trip, a third card; and so on, the path of each pick of the shuttle through the warp yarns being worked out in holes on a separate card. There must be as many cards prepared, therefore, as there are changes in the pattern before the repeat begins, hundreds and sometimes thousands of cards being required in damask weaving. These cards are laced together in an endless chain in the same order as the picks are to occur, and are placed in a frame high over the loom. This frame is so arranged that a card automatically slips into position for use each time the shuttle shoots across the warp; then it passes on, giving its place to the next card, which controls the warp yarns for the next pick. Suspended from this frame over the loom there are long cords holding small steel rods with an eye in the center and a weight on the end. These slender rods are called healds, each of which carries one warp yarn in its eye. Consequently, if there are 5000 warp yarns, there must be 5000 healds controlled from the top of the loom. The drawing of the warp ends through this multitude of eyes in such an order that a material can be woven true to pattern is an intricate mathematical process.

A HEALD

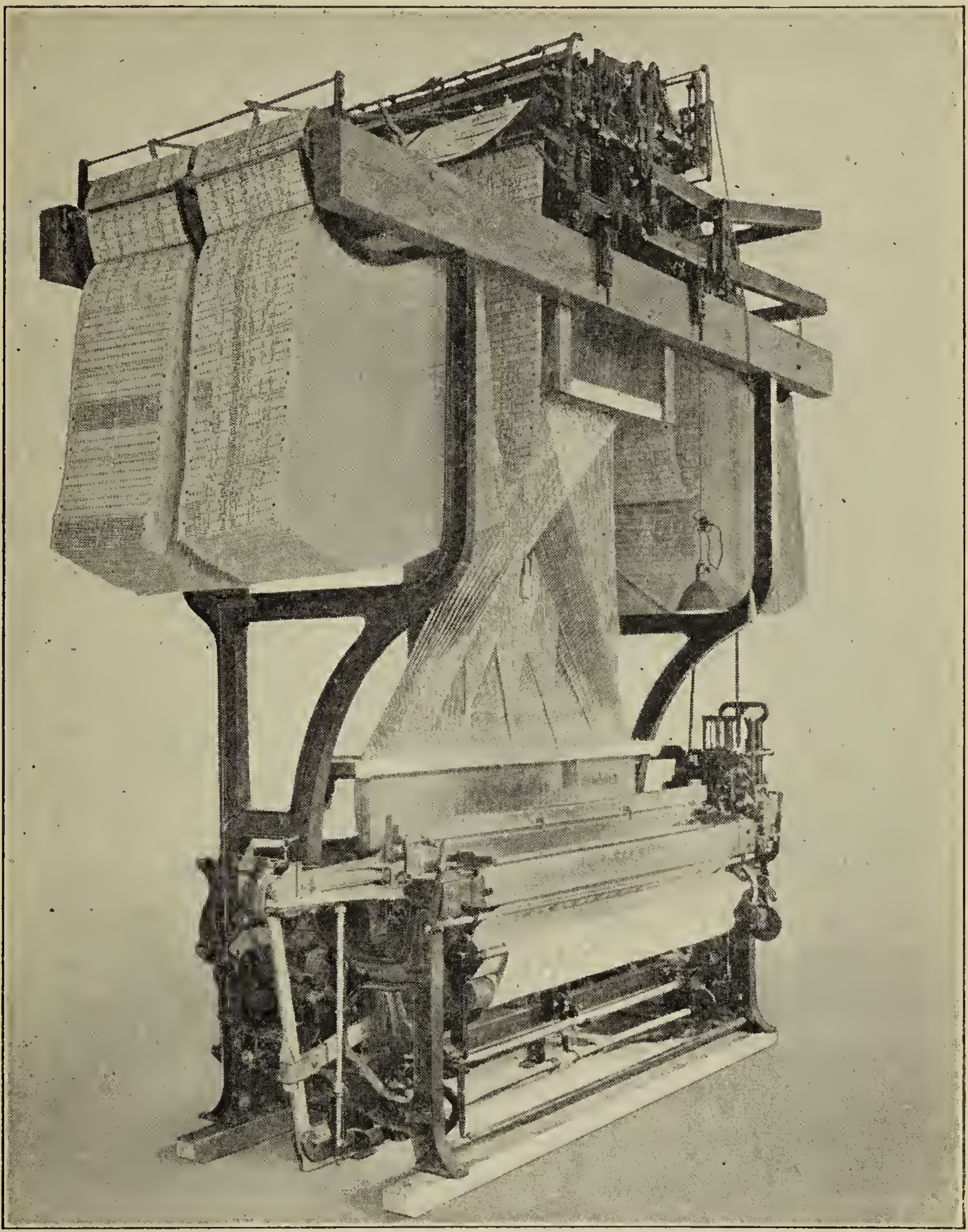
As we watch a Jacquard loom in operation it seems impossible that such a multitude of cords and wires can be controlled automatically. The cords which hold the healds are interwoven into such a dense network that we become hopelessly confused in trying to discover which warp yarn is controlled by any one of them. Only when we see this loom, with its hundreds of cards and its forest of cords, do we begin to realize what it must have meant to arrange all this apparatus. To set up a Jacquard loom is one of the most expensive steps in design weaving and frequently takes a highly skilled man several weeks. For weaving elaborate materials it sometimes takes months to prepare the loom, thus adding greatly to the cost of the fabrics.



DRAWING IN THE WARP

Courtesy of Cheney Brothers

All weaving done by the Jacquard loom is called Jacquard weaving. It is also called figure or pattern weaving, and when found in towels, table linen, or upholstery materials it is often called damask weaving. Perhaps we can now understand why old patterns in table damask persist, why a pattern cloth usually costs more than damask by the yard, why napkins cost relatively more than the tablecloths, and



A JACQUARD LOOM

Courtesy of Crompton & Knowles Loom Works

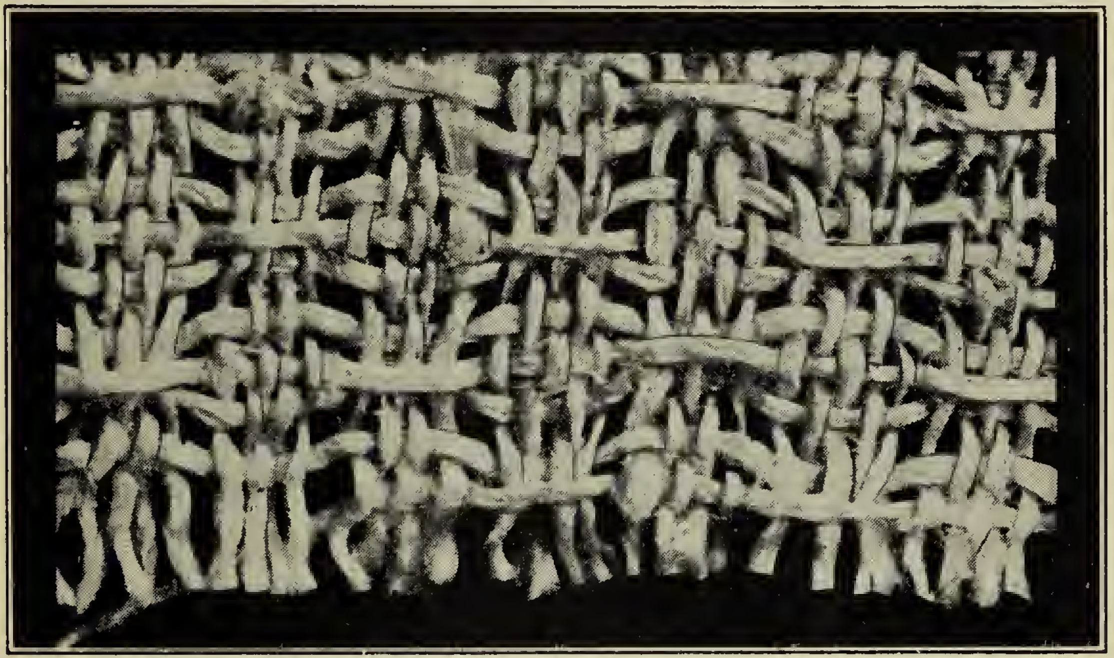
why linens with exclusive designs can command almost fabulous prices. Our beautiful brocaded silks are woven by the Jacquard loom, the fineness of the silk yarns increasing the

difficulty of the problem. Many designs require over 1000 perforated cards, and for the weaving of a brocaded ribbon containing 32 different state flowers, by one of our large silk manufacturers, 10,000 cards were used. It is said that the design for this ribbon when worked out on cross-section paper was 16 feet long and 6 feet wide. The cards when laced together were more than half a mile in length. Do we wonder that brocades, whether in broad silks or narrow ribbons, are more expensive than the same kind of fabric in plainer weave?

Other types of weaving. 1. *Simple figure.* Among our clothing and household fabrics we find cloths with woven figures sometimes covering the entire surface, as in huckaback toweling and bird's-eye linen, or occuring at intervals, as the diamond-shaped figure in shirting or the "snow drops" in cretonne. For these less elaborate designs there may have been used a special attachment to the loom which allows many changes in the lifting of the warp yarns (there are several such attachments), or many harnesses may have been used instead of the expensive Jacquard loom. We now know, however, that woven figures, even though they may be small and inconspicuous, require special apparatus and a special plan for weaving, all of which adds considerable to the cost of the fabric.

2. *Pile.* In the construction of Turkish towels, face cloths, bath rugs, etc. a quite different method of weaving is employed. These articles belong to a class of materials called pile fabrics, and the weave is called pile weave. In Turkish towels the pile consists of loops on both sides, but in some articles loops are found only on the face of the goods. This weave is sometimes called Terry weave and is used in drapery materials, Brussels carpets, and rugs. The loops in pile weaving are made by using an extra set of warp yarns. The warp for the body of the goods is held with a firm tension, and

the shuttle flies back and forth through the sheds as in any piece of plain weaving. The tension of the warp that makes the loops is automatically released at intervals, and that entire set of yarns is pulled forward. The tension is again replaced and, as the cloth is beaten up, these extended yarns appear as loops, first on one side of the material, then on



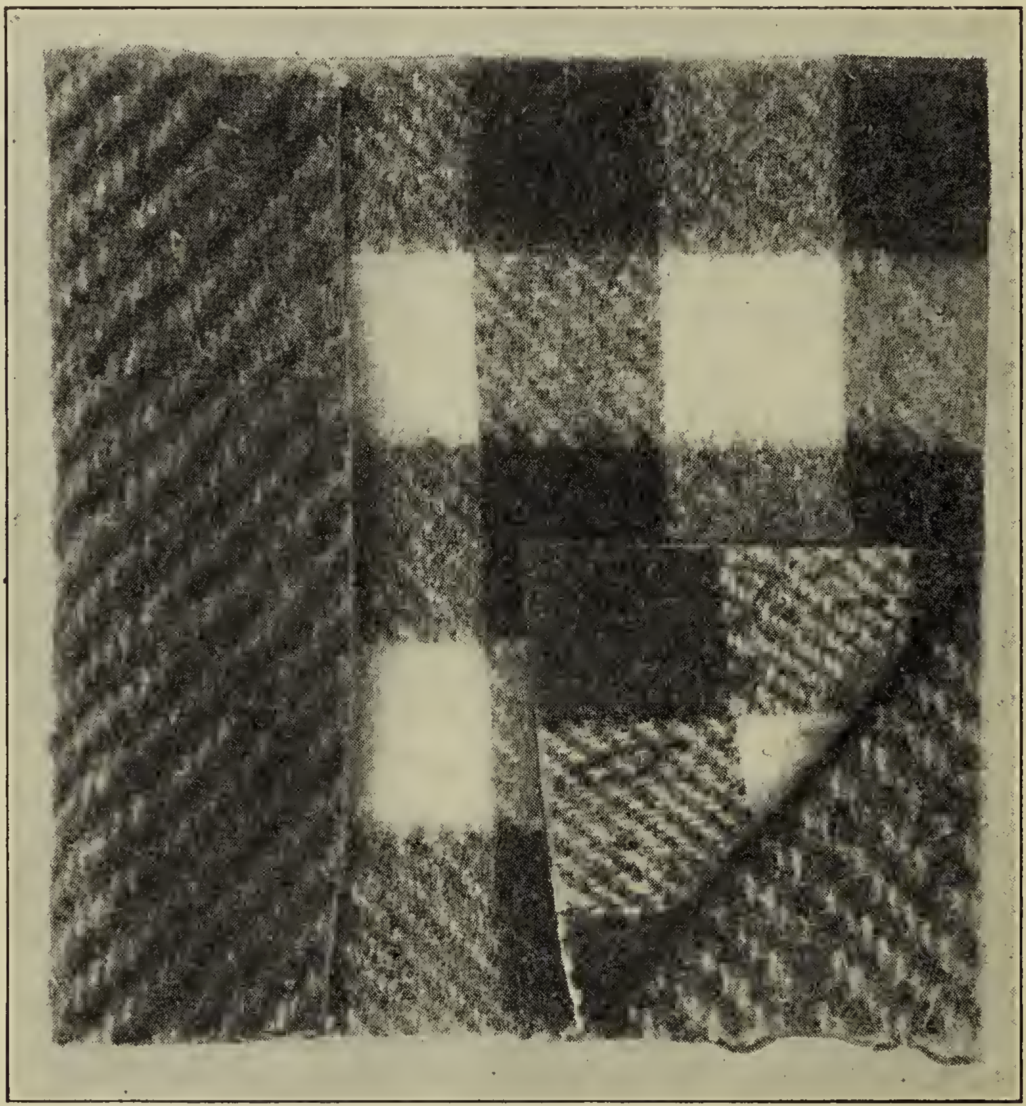
HUCKABACK (MAGNIFIED)

the other. All pile weaving is a relatively slow process, as considerably more mechanism is involved than in simple weaving.

There are many grades of pile weaving, this usually being shown by the price of the article. To give good service the body of the material between the loops should be firmly woven. The body-warp yarns should be strong and close together, so that they may not separate when the towel is pulled widthways. There should be several picks following each row of loops, so that the pile-warp yarns will be firmly fastened and not pull out easily along the length of the towel, like a dropped stitch in knitting. In pile weaving the loops

are sometimes cut as the cloth is woven, producing a cut pile instead of one of loops. Good velvets and plushes are made in this way, as are Wilton and Axminster rugs.

3. *Double cloth.* Have you ever wondered how a steamer rug can be made with such a bright plaid on one side and



DOUBLE CLOTH

such a dark, plain color on the other? Perhaps you have seen a coat or a mackinaw differing in color on face and back. These materials are called double cloths, and their weaving is called double-cloth weaving, — a complicated process open to a great variety of modifications. In the case of the

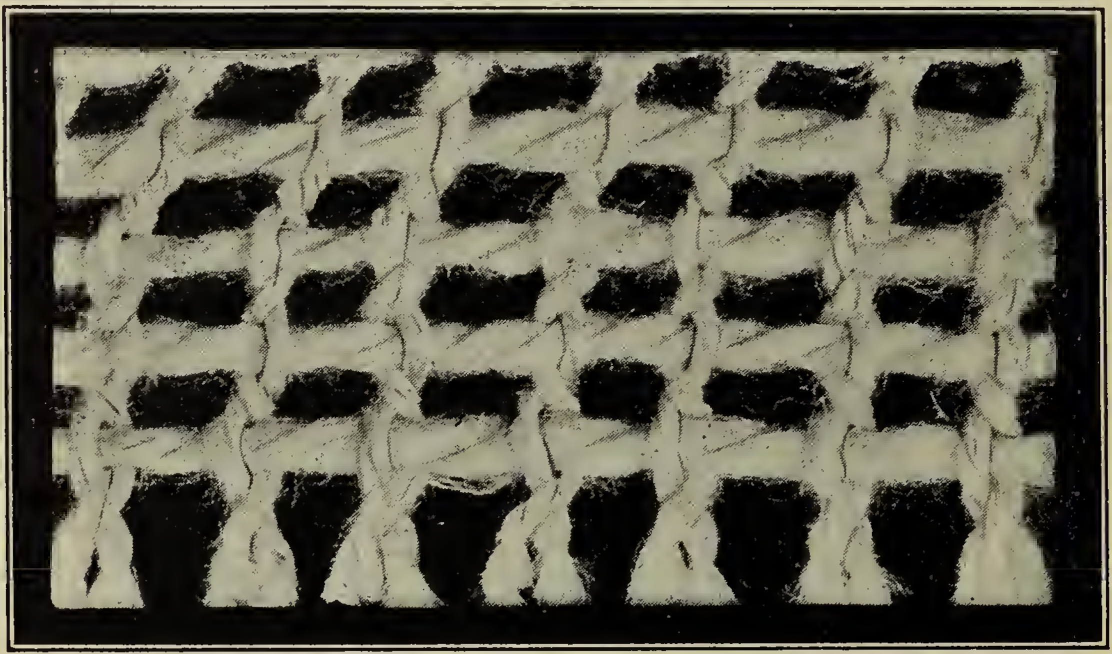
steamer rug and the double-cloth coating, two pieces of cloth, each with its own set of warp and filling, are woven simultaneously on the loom. The two pieces of cloth are bound together at the time of their weaving in one of several different ways. Sometimes the filling yarns of one piece interlace some of the warp yarns of the other. In other cases the two cloths are mechanically stitched together with an entirely different kind of yarn as they are being woven, these stitches not showing on either side of the material. For some fabrics the two sets of yarns weave separately for only part of the time, then combine for the rest of their work, and we have materials like marseilles counterpanes, where there are two cloths in the figures and only one in the background. In certain types of double cloth a special filling yarn passes very frequently between the two cloths, becoming closely woven into the body of both. When these two cloths are cut apart, each one is covered with a pile on one side, made by this special filling yarn. This is the way velveteens, cotton velvets, and some plushes are made, with a filling pile instead of a warp pile, the two pieces of cloth, face to face, being woven at once.

The simplest form of double-cloth weaving is the plain, seamless tube found in pillowcases, hose pipe, lamp-wicks, etc. It is interesting to know that all these tubular fabrics are woven on a flat loom. In these cloths no binding yarns are used, the same filling yarn first interlacing with the upper set and then transferring to the lower set of warp yarns (or vice versa) at the sides of the loom where the selvages of flat cloth are made.

For the beautiful two-faced ribbons that are at times so popular two sets of warp yarns are used, the binding of them together by one set of filling yarns that can hardly be discovered on either face of the ribbon being one of the greatest feats of mechanical weaving. Only one set of warp yarns is used in some fabrics, while two sets of filling yarns are em-

ployed. The soft, "cuddly" bathrobe material that is so much used for infants' blankets and robes contains one set of very fine warp yarns and two sets of coarse and loosely twisted filling yarns. This makes the cloth close and thick and, at the same time, light in weight.

4. *Gauze.* In curtain marquisette we find a weave that is distinctly different from any of the others that we have examined. The warp yarns are arranged in pairs, one yarn in



GAUZE WEAVE USED IN A DISHCLOTH

each pair making a half-twist around the other after each passage of the shuttle. This twisting of the warp yarns about each other gives a very pretty effect to the cloth and adds greatly to its firmness. This is called the gauze or marquisette weave and is found in dress and curtain marquisette and in old-fashioned grenadine. Some dishcloths are made with the gauze weave, as is also the groundwork of the better class of madras curtains. For gauze weaving there is a special arrangement of the harnesses which not only opens a shed but jerks a series of warp yarns first to one side and then to the other, so that they cross each other as the weaving pro-

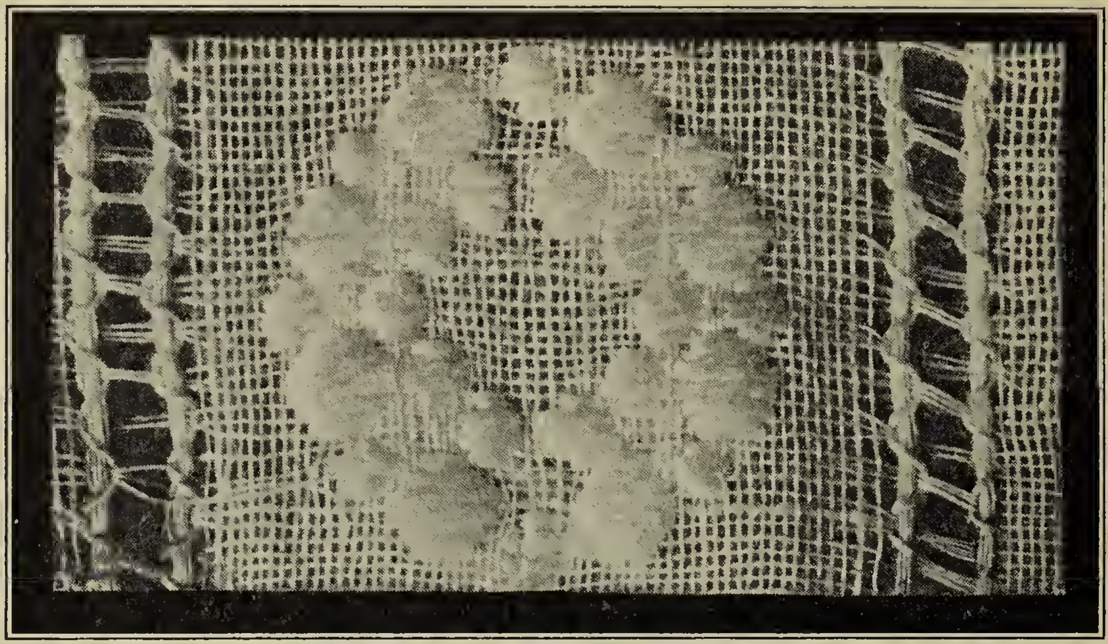
gresses. There are many variations of this weave, caused by different groupings of yarns, but the principle of half-twisting the warp yarns about each other after one or more picks persists in all the forms.

5. *Leno.* A stripe or pattern in gauze weave is often used in cloths of plain weave, producing a fancy effect. This combination is called leno weaving.

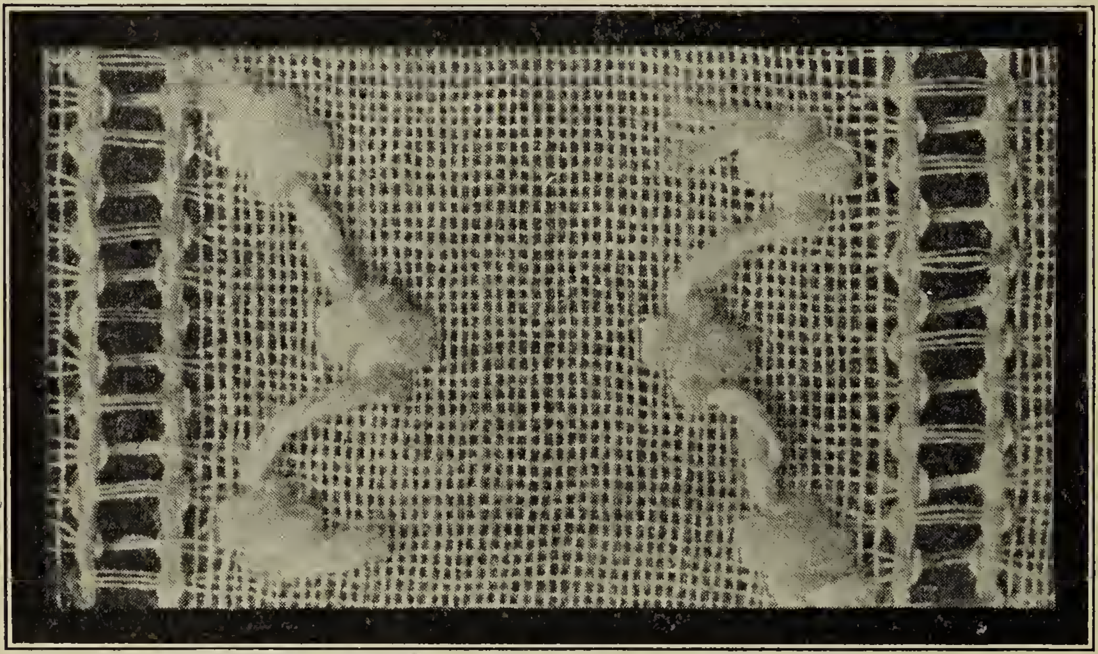
6. *Lappet and swivel.* Dotted Swiss, embroidered voiles, and figured curtain madras present other types of ornamental weaving, the decorative figures being produced simultaneously with the construction of the cloth. In most of these fabrics the foundation, or groundwork, of the material is either a plain or a gauze weave, the figure being made by a special attachment to the loom.

In fabrics where the figures seem to be worked over-and-over like hand embroidery a lappet frame is used and the process is called lappet weaving. In lappet weaving, needles set at right angles to the frames and threaded with the embroidery yarn, or whip thread, are arranged on the loom and operate in such a way as to leave one or more floats of yarn of the desired length in the designed places between the picks of the cloth as the weaving progresses. This allows a very solid dot or figure, which is securely held by the body-filling yarns, to appear on the face of the fabric. The long floats on the back of the goods, connecting the figures, must be cut away during the finishing process ; this requires extra work, causes a waste of embroidery yarn, and considerably weakens the endurance of the figure by the unfastened cut ends that are left. Materials having lappet weave are very beautiful but are relatively high-priced and not suited to hard wear. High-grade Swisses and figured voiles are usually constructed by lappet weaving.

The solid figures in voiles and many dotted muslins are generally produced by an attachment called a swivel frame,

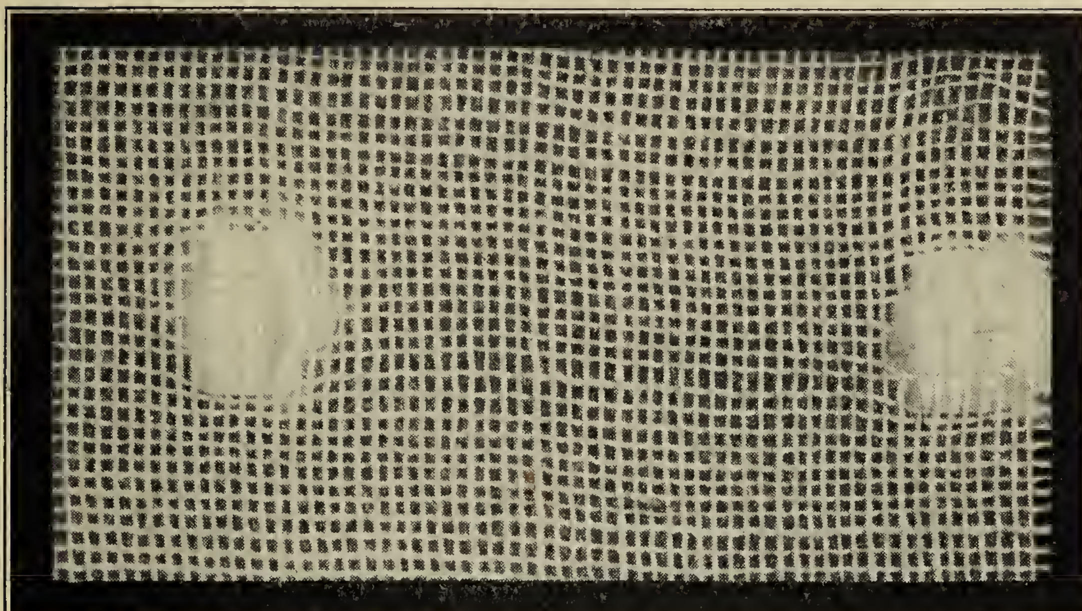


EMBROIDERED SWISS, SHOWING LENO STRIPE AND LAPPET FIGURE (MAGNIFIED)

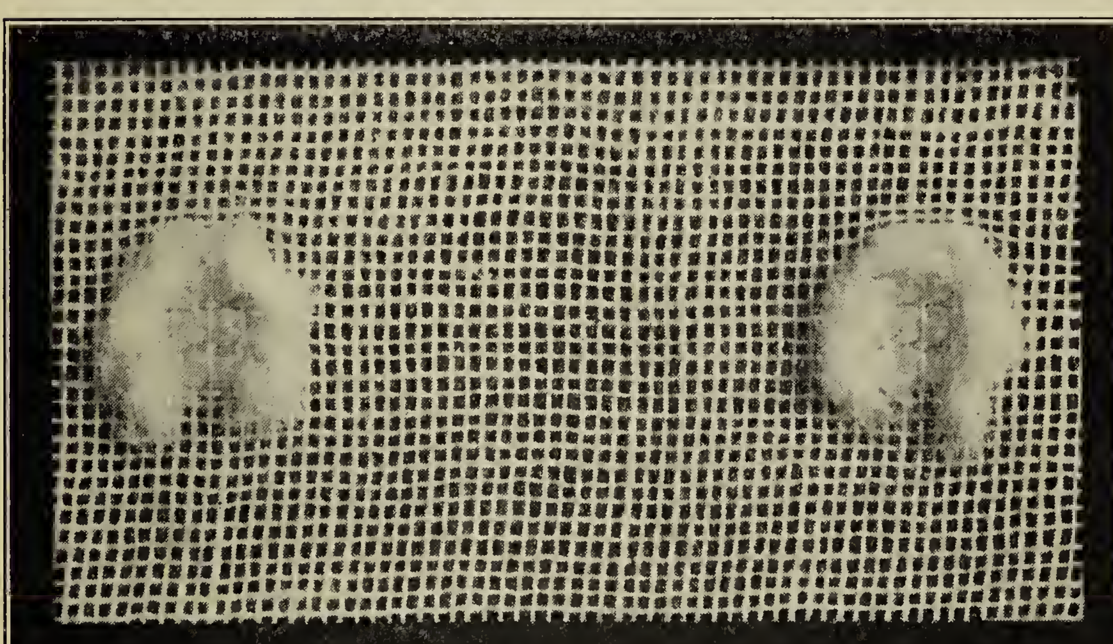


BACK OF LAPPET FIGURES, SHOWING THE CONNECTING FLOATS

the process being called swivel weaving. Each spot in such fabrics is made by a tiny shuttle holding the embroidery yarn and so adjusted in the loom that it appears at prescribed intervals and weaves in the same sheds as those used by the large shuttle carrying the body filling. To produce swivel



DOTTED SWISS WITH SWIVEL FIGURES (MAGNIFIED)



BACK OF SWIVEL FIGURES, SHOWING CUT ENDS

patterns, the small shuttles are arranged from edge to edge of the warp, there being at least one shuttle required for each figure across the width of the cloth. Consequently, in a dotted muslin having a series of twenty-eight dots across its width, twenty-eight tiny shuttles must appear simultaneously, to

weave in the extra filling of which the dots are made. The yarn carried by these small shuttles is automatically cut off at the end of each pick, sometimes producing a shaggy effect at the sides of the figures. Since each spot is completed at the time of weaving, there is no waste of embroidery yarn and no extra finishing operations on the cloth are required. As in the case of lappet weaving, however, the complicated operation of the loom causes swivel weaving to be a relatively slow operation and adds to the cost of the fabric. Swivel weaving wears very satisfactorily, and because of its economical use of the embroidery yarns we often find more expensive materials in swivel than in lappet figures.

The function of weaves. The weaves that have been thus briefly described (the plain, twill, satin, damask, figure, pile, double-cloth, gauze, lappet, and swivel) are the chief weaves found in cloth. There are numberless variations, modifications, and combinations of these weaves, and new cloths continually show new methods of interlacing the two sets of yarns. One weave may be used to produce strength in cloth, another thickness, another beauty, another endurance in laundering, and so on. The suitability of the weave to the purpose intended, the material to be used, and the dictates of fashion at the time must all be decided by the cloth designer long before there is any attempt to produce the cloth by the manufacturer. The reason for the weave selected, however, whether simple or complicated, can always be found by studying the purpose for which the cloth is employed.

QUESTIONS AND ASSIGNMENTS

1. Bring a sample of cloth in each weave mentioned. Bring a sample of at least one modification of each of the fundamental weaves.

2. What weaves are used in the different articles of your clothing?

3. Name a cloth in which the beauty is produced by the weave. Which weave increases the strength and firmness of the cloth?

4. Which weave has the best laundering properties? Name ten materials made with this weave.

5. What is the most common weave found in wool materials? Why is this weave used? How can you tell the face from the back of a piece of serge?

6. Why is the satin weave so much employed in silk materials and so little among wools? Why is it desirable for coat linings?

7. What is the difference between damasks and brocades? (Look up in some cloth dictionary or inquire in the departments where these cloths are sold.)

8. Which weave allows cheaper material to be introduced without destroying the beauty of the cloth? Name a cloth so made.

9. On cross-section paper make a design for each of the three fundamental weaves (see plate in Suggestions to Teachers, p. xix).

10. On a simple loom made from a box, fasten at least 25 warp ends of twine or heavy cord. Across this warp, weave with colored yarn an inch or more of each of the three fundamental weaves.

11. Dissect a fabric not illustrated in this chapter and make a diagram of the weave.

12. If a hand loom is available in your school building, weave some useful article like a table runner, a scarf, or a rag rug. (This should be a class problem.)

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See page 369.

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CHAPTER IV

THE MAKING OF CLOTH: KNITTED GOODS AND THE KNITTING PROCESS

Increase in the use of knitted garments. Woven materials comprise by far the largest amount of cloth manufactured, but the increase of knitted fabrics and garments during the last thirty or forty years is truly surprising. Instead of the bulky "flannels" of our ancestors we now have comfortable, close-fitting undergarments made in sizes to fit any age of either sex. Nearly every person, from the youngest child to the oldest adult, in whatever climate he lives or in whatever occupation he is engaged, wears knitted materials next to the body, while for such garments as stockings, fabric gloves, and sweaters there is no choice in the structure of the material; none other than knitted fabrics are used for such articles of wearing apparel.

One of the most popular uses of knitted goods is in the manufacture of bathing suits. Where, not long ago, women wore voluminous bathing suits of stiff, unyielding materials which became unbearably heavy and presented a most unbecoming appearance when wet, they now demand the light, elastic garments which are knitted. Other sports clothes, such as coats, skirts, caps, scarfs, belts, etc., are frequently made of knitted materials, while at times long knitted capes and entire dresses are the mode of the hour.

The introduction of jersey material (the general name of a plain knitted fabric), whether of silk, wool, cotton, or artificial silk, has been instrumental in greatly increasing the de-

mand for knitted goods. Its light weight, flexibility, and beauty make it a most desirable fabric for all kinds of underwear, dresses and coats, sports suits, and athletic garments. Tricolette, a knitted fabric of artificial silk in a great variety of colors and styles, has been much used for blouses and gowns. These two types of material have added much to the quantity and variety of fabrics for clothing.

Causes of popularity of knitted goods. What is the cause of the great increase in the popularity of knitted goods during the last half century? The chief reason is the superiority, for certain purposes, of cloth constructed by knitting instead of by weaving. In woven cloth, as we have seen, there are two sets of yarns interlaced at right angles to each other. All the yarns, particularly those of the warp, are held with a strong tension during the weaving process, so that the finished cloth usually stretches very little. This method of construction causes woven fabrics to be characteristically firm and self-supporting. Clothing is usually cut lengthwise of the goods, the weight of the garment being sustained by the warp yarns, while the strain from the movements of the body in wearing is along the filling yarns. Is it not true that if any of our garments made from woven cloth are subjected to an undue amount of pull or strain in any direction, the result is usually broken yarns, causing a torn place, instead of stretched yarns, causing a loose or misshapen place?

1. *Advantages of looped construction.* Knitted cloth is formed by continuously interlooping one or more strands of yarn. With knitted materials the effect of a pull or strain is quite different from that on woven cloth. Instead of breaking, the yarn slips easily from stitch to stitch, tightening up on those that are bearing no burden and loosening and relieving those that are standing the strain. At the end we may have a garment quite changed in shape but usually uninjured

in structure. This characteristic of knitted goods to bend instead of break, to stretch instead of tear, to lose shape rather than lose strength, makes it a highly desirable material for underwear and all kinds of body garments.

2. *Light weight of knitted garments.* The coming of the athletic girl has greatly increased the use of knitted underwear. When made out of woven cloth, garments require extra fullness, in order to give room for the movements of the body. Success or pleasure in sports can be gained only by the free use of all the muscles, and bulky, clumsy undergarments are a serious drawback to freedom of movement. With snug-fitting but elastic knitted underwear this necessary freedom is obtained.

If you have in your possession a chemise or a petticoat from the wardrobe of your grandmother or great grandmother, look at the amount of cloth that is used in the garment. The articles in a bride's trousseau of those days were wonderfully beautiful in workmanship and quality of material, but we are very glad we can wear simpler, lighter-weight garments.

3. *Hygienic and sanitary properties.* Knitted underwear is more comfortable and hygienic than flannel or muslin underwear for another reason. Being more porous, it more readily absorbs moisture than woven goods, making it better to wear next the body. This same porosity allows knitted fabrics to be cleansed more easily than woven fabrics; therefore knitted underwear is more sanitary than that made from muslin or flannel. As knitted garments require little or no ironing, the ease with which they can be laundered is unsurpassed by any other material.

Early days of knitting. Like the beginnings of weaving and spinning, the origin of the knitting process will probably always remain in obscurity; there are no indications, however, that it was one of the early arts. No specimens of knitted materials have been found among the prehistoric

fabrics, and no mention of the word *knit* can be found in any of the writings before the year the New World was discovered,—1492. In the olden days all knitting was done by hand, and probably the same principles were employed as were used in hand knitting more than four hundred years later, for the soldiers and sailors during the World War. While sweaters and helmets were made with a very simple stitch, it took most people considerable time to construct one of those garments of the right shape and size. In the knitting of socks many unsuccessful attempts were frequently made before one with an acceptable heel was produced. The early days of knitting, therefore, like the days of weaving before the invention of machinery, were a period of slow production and little variety of fabrics. But, as mechanical means always follow the slow, monotonous hand process, so a knitting machine, called a stocking frame, was at length introduced into the knitting industry.

Invention of the stocking frame. It is interesting to learn the real causes of a new discovery or invention. Sometimes it seems to be a flash of genius which is born in the individual, like the discovery of the power of steam by Watt and of electricity by Franklin. Sometimes the discovery or invention is the result of a struggle to satisfy an insistent demand on the part of the public affected; Hargreaves' spinning jenny resulted from an effort to produce more yarn, and Roberts's automatic loom, from his attempt to produce more cloth. In the case of the stocking frame, however, neither of these causes seems to have been the reason for the invention. If we read correctly from the records left, an attempt to make a better living by knitting stockings much faster than could be done by hand was the real cause of the invention of the stocking frame. In 1589 William Lee was the poorly paid curate of a little village in Nottinghamshire, England, and the story of his struggles, success, failure, and disappoint-

ment is very similar to the story of John Hargreaves, who invented the spinning jenny nearly two hundred years later.

Hardships of the inventor. It is said that the Reverend William Lee studied the movements of his wife's fingers in knitting, finally evolving a machine which employed the same principles and would produce the same kind of material. As those were the days of the guilds and hand knitters, it was necessary for Lee to obtain a right from the queen to produce machine-knitted fabrics. Queen Elizabeth, fearful that knitting machines would deprive the hand knitters of their work, refused him the right to knit any but silk stockings, which she felt sure he could not do. The granting of this meager privilege was to William Lee a challenge and caused him so to improve his machine that satisfactory silk stockings could be knitted upon it. The feeling of the hand knitters was strongly against him, however, and, finding that he could make no progress with his invention in England, he fled to France, where the king welcomed him heartily. France was at the time in an unsettled political condition, and after the king, Henry IV, had been assassinated, William Lee, with others, was thrown into prison. History tells us that he died a poor, broken-hearted man and was buried in an unknown grave in France.

The principles of knitting, however, had now been applied to a machine, and the achievement was bound to live. By 1640, about fifty years after Lee's struggles with the invention, stocking-making by machinery was one of the principal industries in the villages of Nottinghamshire, and seventy-five years later there were over eight thousand knitting frames at work in England.

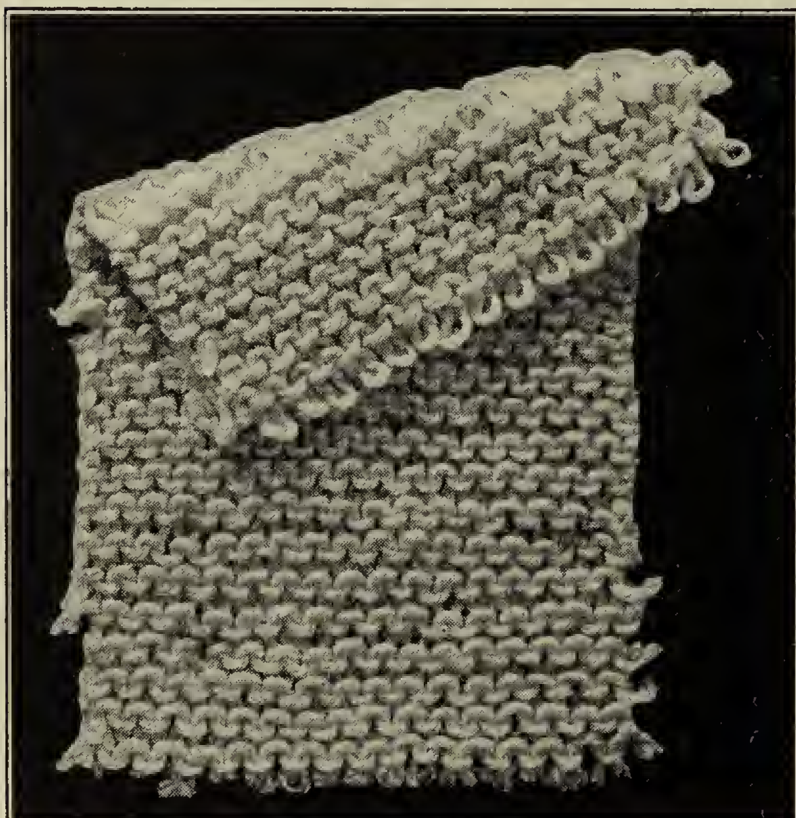
Additional inventions. The eighteenth century was a period of invention, most of the primary inventions connected with spinning and weaving appearing between 1730 and 1830. During this same period numerous improvements of the

knitting machine were made. Mechanical devices for making the tuck stitch which is the foundation for the popular cardigan stitch of our heavy sweaters, the ribbed stitch which is always used for the parts of our garments where special elasticity is required, the eyelet holes now used in mesh underwear and knitted lace hosiery, the "warp knitting" process which is the basis for the milanese stitch used in silk gloves and underwear, and the great variety of ornamental stitches used in sweaters, golf hose, etc. were all invented during that time. Circular knitting machines also appeared during this period, introducing the knitting of tubular fabrics. These later inventions were all worthy achievements, and the names of the inventors will live in the history of the textile world; but to William Lee, the poor English curate who received only hardships and persecution for his effort, belongs the honor of having made possible the great knitting industries of the present day.

Fundamental stitches. As there are a few fundamental weaves employed in woven fabrics, each one giving to the cloth a characteristic that is especially desirable for a particular purpose, so among knitted fabrics there are a few fundamental stitches, the character of the cloth being governed by the stitch used in its construction.

1. *Purl stitch.* Probably the simplest form of hand knitting is the flat fabric constructed with two needles, the entire number of stitches being knitted from one needle onto the other, the work then turned and the stitches knitted back onto the first needle. This produces a fabric alike on both sides, and one that stretches lengthwise. The technical name for this stitch is *purl stitch*, but in our early Colonial history it was called garter stitch, as the women in those days knitted their own garters. This is the stitch used where-ever lengthwise stretch is required, as in scarfs, puttees, sleeveless sweaters, and little children's sweater suits.

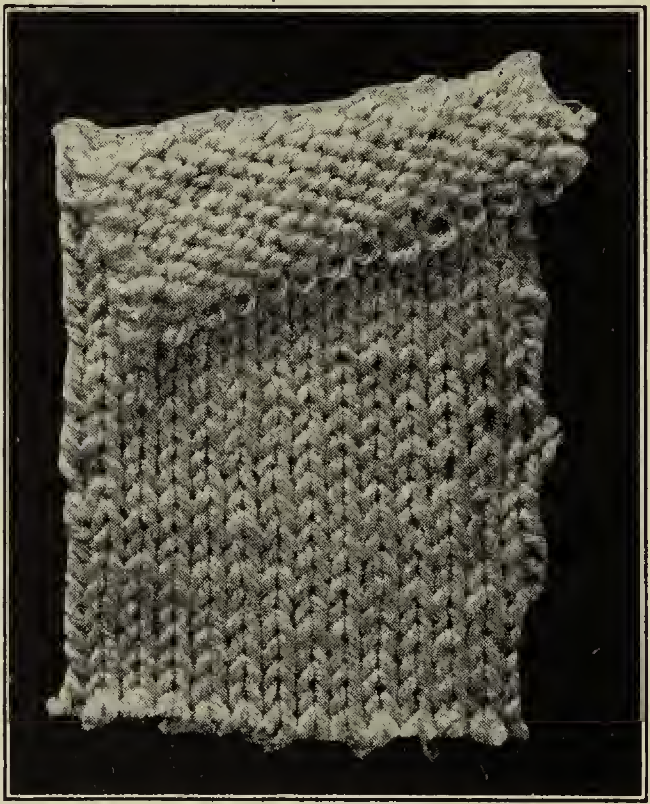
2. *Plain or jersey stitch.* While the purl stitch is the simplest stitch for hand knitting, it was not the one to be first made by a machine. Instead the plain stitch used in men's and women's hosiery was the one whose principle William Lee worked out in his early invention of the stocking frame.



PURL KNIT

Did you, as a child, ever knit a pair of reins by continuously looping a strand of yarn over four pins stuck into the end of a spool? If you never did, you missed the fun of seeing this long, slender rope of brightly colored bits of yarn that perhaps mother or grandmother gave you, grow from the bottom of the spool. The stitch in knitted "play reins" is the same as that used in knitting stockings. It is called plain stitch, and the face and the back of the fabric differ in appearance. The right side, or face, of the material is smooth and shows the part of the yarn that makes the sides of the stitches, which form lines called *wales,* running lengthwise of the material. On the back of the fabric the tops and bottoms of the stitches make crosswise ridges called *courses.* In woven cloth the fineness of the fabric is determined by the size of the yarn and the number of picks and ends to an inch. In

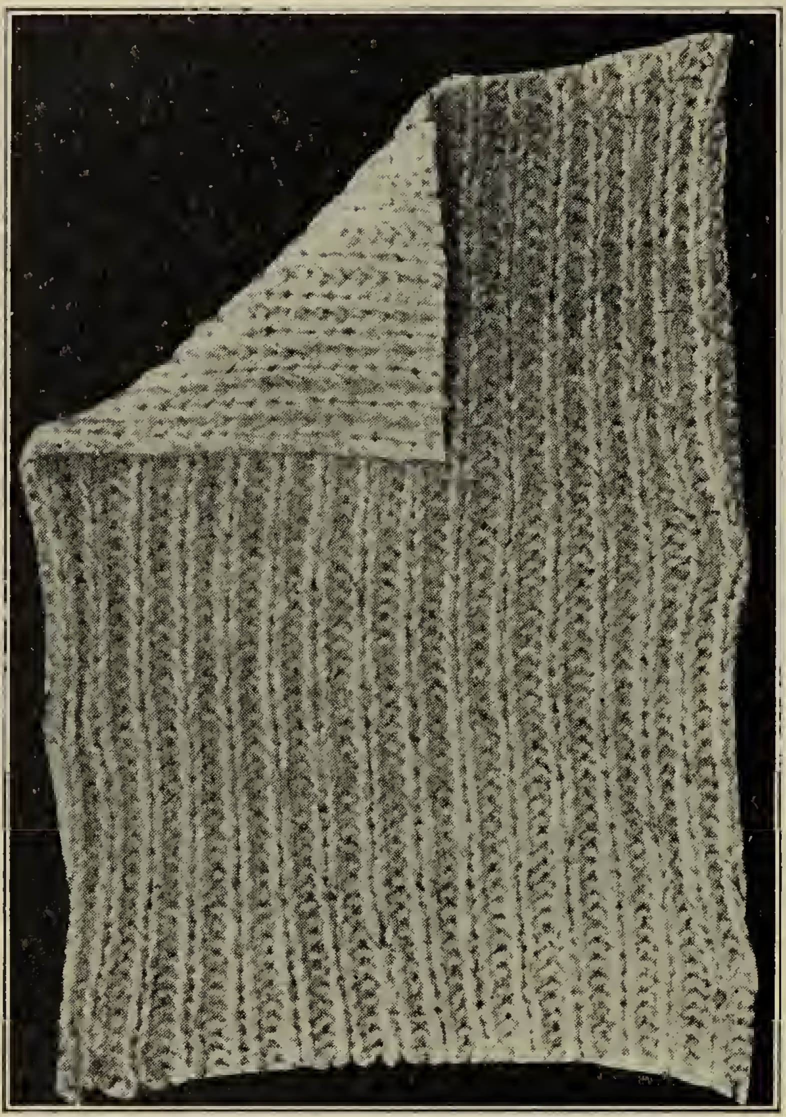
knitted fabrics the fineness is determined by the size of the yarn and the number of stitches to an inch (measured along a course). In a low quality of seamless hosiery there may be as few as five stitches or needles to an inch (in machine knitting each stitch along a course is formed by a separate needle), while in better grades there are more than twenty. For his finest full-fashioned goods a certain large American hosiery manufacturer uses thirty-four needles to the inch. The lengthwise stretch of the plain stitch is much less than that of the purl stitch, and consequently it is used for garments that are expected to retain their original length. Plain stitch is the popular stitch for articles of clothing in which a smooth, plain face is desired, and is the one universally employed in stockings, whether of silk, wool, or cotton. Some kinds of underwear are made with the plain stitch, as are also dress materials, bathing suits, coats, and sweaters. It is the stitch found in the linings of rubber footwear, the reason for its use here being apparent. Heavy woolen gloves, mittens, and caps are made with this stitch. The plain stitch is often spoken of as *framework knitting* (its early name), and though it can be employed in flat cloths, its most rapid production is of tubular fabrics.



PLAIN KNIT

Note wales on face and courses on back of material

3. *Rib stitch.* Another stitch that is much used in our knitted garments is the rib stitch, which produces a fabric with lengthwise ribs on both sides. This is the stitch used in hand knitting when directions read: "Knit one, purl one." Where the same number of stitches is knitted as purled, both sides of the fabric are alike. The "one and one" rib (also called "twin needle") produces the material that is so much used in knitted underwear and boys' stockings. The "two and two" is called the Swiss rib and is found in undergarments. Rib stitch is open to many variations and is used for decorative as well as for practical purposes. By varying the number of stitches in either plain or purled ribs many different effects may be produced. Besides being very elastic crosswise, and therefore admirably suited to underwear, the rib stitch much increases the warmth of the garment; for if the ribs are not stretched apart, the material



RIBBED MATERIAL; "ONE AND ONE" RIB, OR "TWIN NEEDLE," STITCH

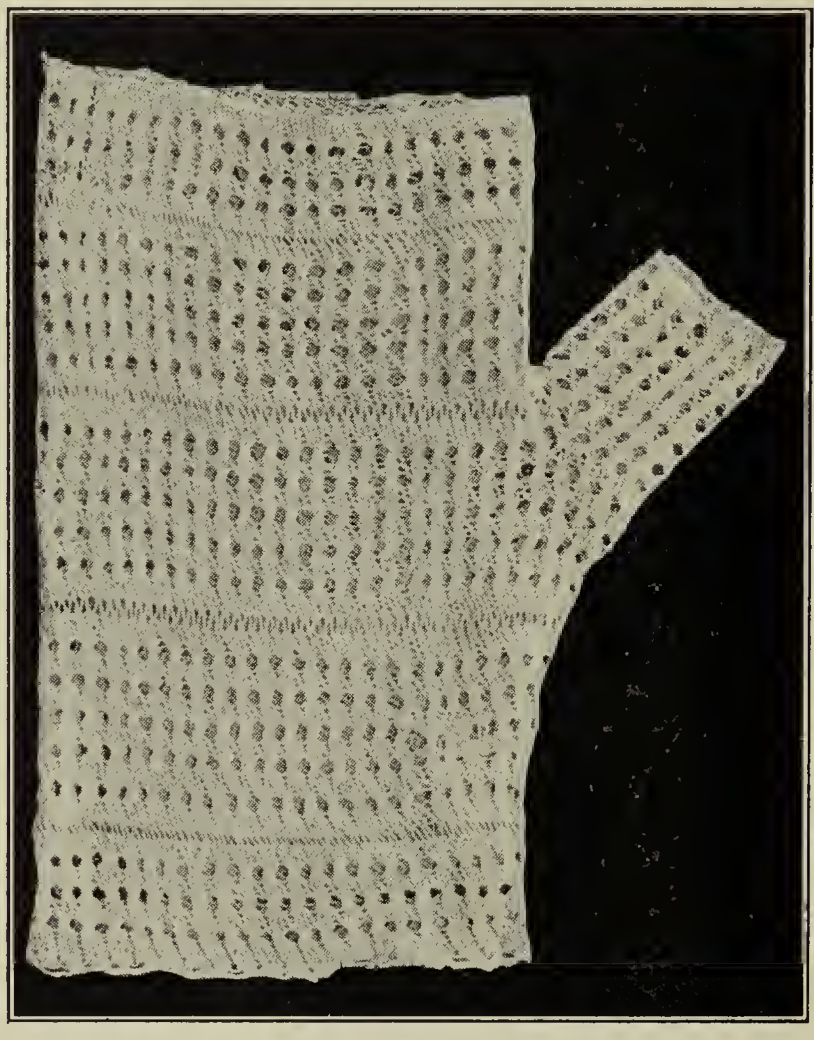
is almost double in thickness. The rib stitch is used in plated goods with yarns of different colors or of different fibers, one yarn being thrown to the front on the plain ribs and the other being thrown to the front on the purled ribs.

In plain plated knitting two yarns are used together in the knitting strand, these yarns differing in color or material. By a device on the knitting machine either of these yarns can be thrown to the front as desired. Beautiful effects can thus be produced in color, while very durable and attractive goods can be produced more cheaply by a combination of a poorer grade of yarn with an expensive one than as if they were made entirely with the better material. Plated silk stockings are made with one yarn of silk, which is always thrown to the front, and the other yarn of lisle. This combination makes an attractive and satisfactory stocking which can be sold at a lower price than one of the same weight made entirely with silk. Plated angora sweaters and scarfs usually contain a woolen yarn of lower quality, which, if knitted with the "one and one" rib stitch can hardly be detected. This method of construction produces two-toned materials, the black-and-white combinations being especially effective.

Other useful stitches. These three stitches, the purl, the plain, and the rib, are the fundamental stitches in simple knitting. By the use of different colors and kinds of yarn, and different lengths and combinations of these stitches, a great variety of patterns can be worked out in knitted materials. Less common stitches are often introduced, however, to give shape or decoration to a knitted garment.

1. *Tuck stitch.* The tuck stitch, or loop accumulation, as it is sometimes called, may be used with any of the three fundamental stitches, making knobs or prominences over the surface of the material. The tuck stitch consists of slipping, instead of knitting, certain stitches from one needle to the other across one course, then knitting them in regular order on the next course. These unknitted stitches slip, or "tuck," behind the knitted ones, causing little bunches which change

the appearance of the fabric. A large number of designs can be produced with the varied arrangement of the tuck stitch, especially by the use of different-colored yarns. This stitch is much used in neckties, scarfs, mufflers, and shawls.



A HAND-KNITTED MITT NEARLY A HUNDRED YEARS OLD

2. *Half cardigan or royal rib.* The stitch known as the half cardigan or royal rib is made by use of the tuck stitch with the rib stitch. This combination increases the thickness of the fabric and decreases the stretch crosswise, producing a warmer, heavier material for outside garments.

3. *Full cardigan or polka.* These characteristics are further accentuated in what is known as the full cardigan or polka stitch, which is used in knitting garments that are to

endure hard wear, as heavy sweaters and jackets. This stitch has given the name *cardigan* to a man's coat of this material. For such heavy garments large yarns are often used, sometimes as many as twenty strands being put together ("doubled," as it is called) for the knitting yarn.

4. *Open stitch*. The open stitch is much employed for ornamental open-knit, or lace-knit, stockings, childrens' socks, babies' bonnets, cellular underwear, and face cloths. In hand knitting this stitch is made by throwing the yarn over the needle and knitting the next two stitches together at prescribed intervals across one course. In the next course those strands that were thrown over the needle are knitted as regular stitches. This causes an open space to appear between the stitches without impairing the firmness of the material. By following a carefully worked out design these holes can be arranged to produce a very beautiful lace effect, and before the invention by Heathcoat of a machine for making a fast-meshed net all machine-made laces were knitted. Throwing the yarn over the needle to form a new stitch is one method of increasing the number of stitches or widening the work, while the knitting of two or more stitches together decreases the number of stitches, or narrows it.

These two principles, widening and narrowing, give to knitted fabrics a property that can in no way be approached by woven fabrics, that is, the property of *shaping* a garment or the sections of the garment at the time the cloth is being made. With woven materials the garment must be cut out and made *after* the cloth is produced; with knitted materials the garment can be constructed *at the time* the cloth is manufactured. The effect of this property is shown in the rapidity with which seamless underwear and hosiery can be produced and the consequent lower price of these garments.

Jacquard, or loom, knitting. As the varieties of patterns in woven fabrics were astonishingly increased by the use of the

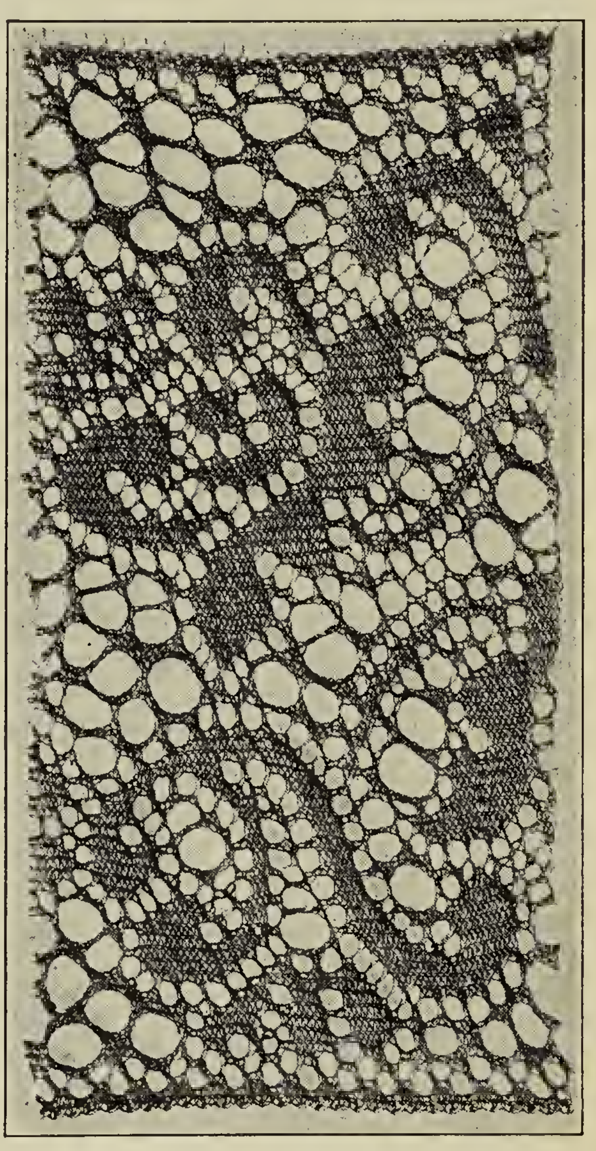
Jacquard system of selecting the warp yarns to be lifted, so, in a similar manner, to certain kinds of knitting frames or looms a Jacquard attachment can be applied, to select the different needles that shall knit during each course. Consequently, when we admire the elaborate knitted designs in the tops of golf stockings, in neckties, and in babies' bonnets, it is very probable that the wonderful Jacquard system controlled the needles which knitted the particular colors or the particular stitches of which the design is formed.

The production of knitted goods by ornamental or intricate stitches is usually a slow process, accomplished by highly complicated and expensive machinery. For making a certain brand of two-toned ribbed hosiery it took nine months to set up the machine, while the erection of a lace machine for making openwork stockings required more than a year's time of two well-paid men. If these expenses are known or considered by the one who buys knitted goods with beautiful designs, the prices asked will not appear so excessive.

Warp knitting. We now see that knitted fabrics are a wonderful addition to our world of cloth, though we are only beginning to appreciate their possibilities. The chief disadvantage of these materials to many people is the long open place made in the cloth if a stitch is broken. The familiar "runs" in the legs of stockings illustrate this disadvantage. To be sure, the manufactured dropstitch fabrics are very ornamental, but dropped stitches appearing at unexpected places in a garment mar its appearance and decrease its strength. A system of knitting in which a broken stitch does not produce a run is now in common use. It is called warp knitting and cannot be produced by hand. In simple warp knitting, chains of stitches are joined by their sides, making a firm fabric which does not easily ravel. The frame for plain warp knitting, which is called a chain loom, is a highly complicated machine, expensive and relatively slow

of production and requiring a skilled and experienced operator. Consequently the fabrics produced by warp knitting are made of expensive yarns and usually command a high price.

Although most warp-knitted materials are flat, a few looms are made to produce tubular fabrics. Our familiar gas mantles are knitted on a circular warp loom, and some tubular warp-knitted neckties are produced. Many of the warp-knitted fabrics so closely resemble those that are framework knitted that it is difficult to detect the difference by their appearance. In fabrics constructed by the warp loom, however, all danger of "runs" has been removed.



KNITTED LACE

Types of knitted fabrics. It is quite impossible to name and describe in one chapter the different fabrics made by the knitting process. There are the flat, straight-edged warp-knitted piece goods, or webs, from which individual garments are cut and made. Milanese underwear, good fabric gloves, and glove-silk stockings are made from this kind of material. There are the flat, selvaged pieces shaped, or "wrought," as they are knitted in the size and form necessary to use in the garment. Our full-fashioned stockings, many of our sweaters

and coats, and much of our better quality of underwear are knitted in these shaped pieces and sewed together. The production of wrought knitted goods is much slower than that of straight-edged piece goods, or webs, made with the same stitch. Garments constructed from these shaped pieces are highly satisfactory in fit and usually contain excellent material. Plain tubular fabrics from a circular knitting frame can be produced faster than any other kind of knitted goods. Many garments can be cut at one time from these webs, or tubular pieces may be pressed into the shape of underwear and stockings, much reducing the expense of their manufacture. The difference in price between full-fashioned and seamless hosiery is easily explained if the two methods of production are understood.

FACE AND BACK OF A KNITTED SILK GARMENT

Note the horizontal rows of chain stitches on back of fabric

Comparison of knitted with woven goods. In comparing knitted with woven materials we find that each occupies a distinctive place in the fabric world. Because of their lightness, shapeliness, elasticity, and porosity knitted goods

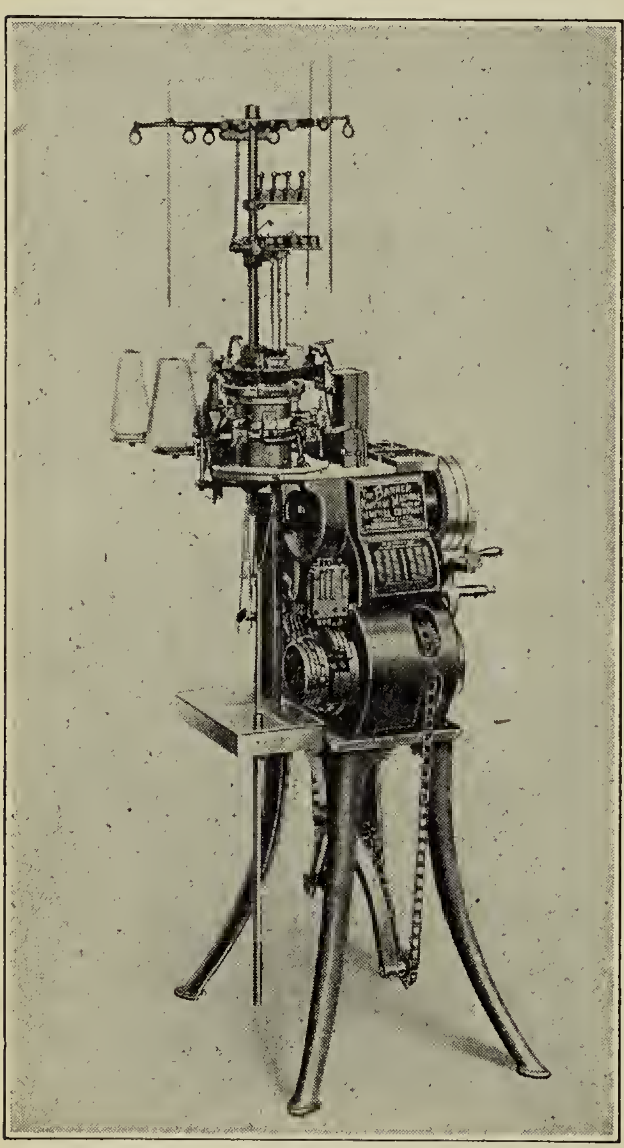
are unsurpassed for underwear. With the frequent introduction of new yarn combinations and stitch effects knitted materials seem likely to rival in beauty our most attractive woven fabrics, and for a large number of purposes they far outclass, in usefulness, cloths constructed by weaving.

But knitted fabrics can never supplant woven goods for general purposes. The elastic quality that is so desirable for underwear prevents knitted goods from holding their shape on all occasions. They invariably stretch more than woven fabrics. Though knitted materials do not tear as readily as woven goods, their appearance is easily marred by a pulled stitch, or "snag." Silk stockings are often ruined in appearance through the pulling of a stitch by a ring or rough finger nail.

THIS BEAUTIFUL COLONIAL COSTUME COULD NEVER BE PRODUCED WITH KNITTED FABRICS

Finally, knitted materials are adapted to only certain styles of outer garments. In the reign of straight lines and clinging garments knitted materials enhance the desired effect;

no "fluffy ruffles" can be produced with tricolette or jersey; but if the old-time fashions of crinoline or hoop skirts ever return, knitted dress fabrics will no longer hold sway.



A STOCKING-KNITTING MACHINE

Courtesy of Hemphill Company

Knitting in the United States. Machine knitting was begun in the United States early in the nineteenth century. England which gave birth to most of the textile inventions, jealously guarded its secrets and allowed no machines or parts of machines to leave the country. The United States was eager to engage in textile manufacturing, and continued attempts were made to bring the machines to this country. The first stocking frame was brought here secreted in a cargo of salt, and was set up in Ipswich, Massachusetts, in 1818. The Ipswich Knitting Mills are now among the largest in the country. In 1825 the first knitting mill (where many machines were assembled under one roof) was established at Germantown, Pennsylvania. At the present time Pennsylvania leads in the manufacture of knitted goods and hosiery. Massachusetts and Wisconsin also produce great quantities of knitted goods, and knitting mills are found in many other states.

Although the early knitting inventions were by people in other countries, the seamless-hosiery machine is an American invention. This machine, which was invented in 1880, is responsible for the great increase in seamless hosiery and underwear since that date. Of the present automatic circular knitting machine an English writer[1] says:

> In the old days a worker on the hand frame would produce a few pairs of hose or one or two articles of underwear per day. At the present time one operator can produce up to 150 dozen pairs of army half-hose on a set of machines. A circular knitting machine containing 240 needles and running at a speed of 300 revolutions per minute makes no less than 72,000 perfect loops a minute from a single weft thread, and knits up the yarn at an average rate of one mile in six minutes.

Since the invention of this machine our country has stood first in the production of plain tubular fabrics and in the manufacture of automatic machines for plain knitting.

QUESTIONS AND ASSIGNMENTS

1. What article of your clothing is always knitted? What other knitted garments do you possess?

2. Compare knitted fabrics with woven ones.

3. There are full-fashioned, semifashioned, and seamless styles in women's stockings. Compare the three styles as to appearance, fit, difficulty of construction, and price. (Get information from stores and from the experience of wearers.)

4. Give the advantages and disadvantages of glove-silk stockings.

5. Why are knitted garments desirable for underwear?

6. What care should be taken in washing a knitted sweater? From your own experience or that of some friend give directions for washing a sweater.

7. *Cashmere*, *merino*, *balbriggan*, are terms that are frequently met in knitted goods. Give the meaning of each.

[1] Chamberlain and Quilter, Knitted Fabrics, p. 14.

8. Visit the infants' department in any store and list the articles that are knitted. Why is this method of construction used so much for infants' clothing?

9. Is there a knitting mill in your state? Where? What does it manufacture?

10. What are some of the well-known brands of stockings and knitted underwear? Where are they made?

11. With bone or steel knitting needles and cotton or woolen yarn do one piece of knitting in each of the three simple stitches described, purl stitch, plain (or jersey) stitch, and rib stitch. (It is desirable for the class to knit useful articles illustrating all these stitches; for example, a face cloth in purl stitch and a pair of men's socks showing both the rib and the jersey stitch.)

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See page 369.

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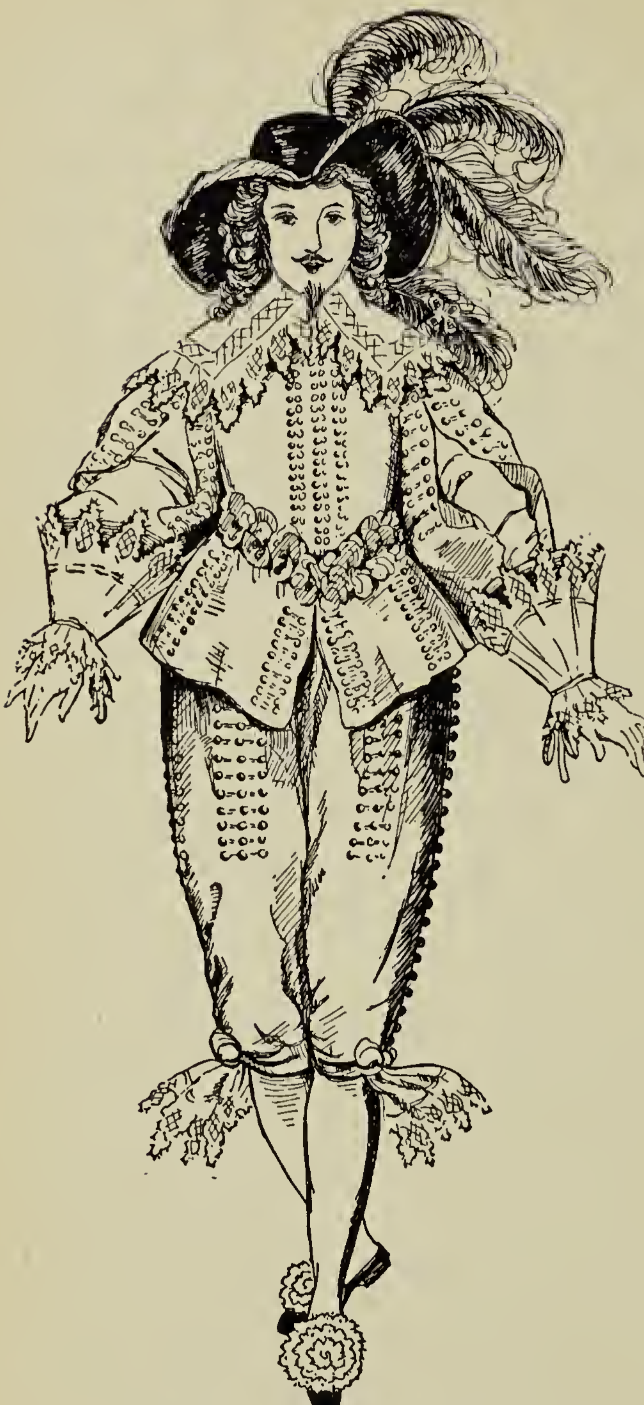
CHAPTER V

THE MAKING OF CLOTH: LACE AND LACE MAKING

Lace, as we know it, was probably not made before the fifteenth century, but its history is so tied up with love and law, romance and religion, that we approach its study with keen anticipation. There are at the present time two distinct kinds of lace: hand-made, or real, lace and machine-made, or imitation, lace. Machine-made laces have been manufactured for more than a hundred years, but in order to understand and appreciate these imitations it is necessary to know something about the real laces which preceded them.

Origin of lace. To a far greater extent than weaving or knitting, lace making continues to be a hand industry. When and by whom it was begun we do not know, but remains of beautiful lace in the form of cut, darned, or drawn work have been found in old Roman and Egyptian tombs, and it is known that lace making was an ancient art with the Arabs and Armenians. So it would seem safe to conclude that the making of this ornamental fabric originated at a very early date with the people in and around Asia Minor.

Lace in the seventeenth century. Lace was used at first almost entirely in religious ceremonies, and the making was confined to the nuns within the convents. Gradually, however, the art of lace making was learned by the ladies of nobility and was spread by them until this industry, in some



A LACE-TRIMMED COSTUME OF THE SEVENTEENTH CENTURY

From Pauquet frères

form, was carried on by nearly all classes of women throughout Europe. We are told that in the early part of the seventeenth century it seemed as if the whole world were either making or wearing lace. It was put on every garment of both men and women, even their boots and shoes being decorated with big bows edged with lace. In fact, during this period society seemed to go mad over the beautiful fabric, and many people actually went bankrupt to buy lace. As a result, laws and edicts were issued at different times by the popes and the kings, forbidding the wearing of lace by certain classes of people or limiting the value of the laces worn. Such edicts, which always brought great hardship to those who earned their living by making lace, were frequently revoked in a short time and the lace-making industry revived. The French Revolution did away with all lace making in

France, but when Napoleon came to the throne he decided to bring back the ancient art and ordered a complete wedding outfit of lace for his bride. He also made lace wearing at court obligatory and in other ways tried to encourage the lace makers to take up their work again.

Legendary beginnings of hand-made lace. About the middle of the sixteenth century two methods of making lace sprang up almost simultaneously in Europe. One, in Italy, was by the use of the needle, producing what has always been called needle-point lace; and the other, in Belgium, was by the use of bobbins, giving birth to our many well-known kinds of bobbin lace. The legends that account for these inventions are as follows:

A fisher boy of Venice was commanded by the Doge to go to war against the Sultan. He gave as his parting gift to his sweetheart a branch of coral. All the time that he was away she kept the branch in her sight as she worked on a net that was, by its strength and perfection, to show him her love. At last the net was finished, and upon that very day the fisher boy returned. Wild with joy, the maiden brought out the net, and behold! in the middle was woven a copy of the coral.

In Bruges lived a lover and his sweetheart. The maiden's mother was desperately poor, and the maiden vowed that if some miracle would happen which would allow her to properly care for her mother, she would renounce her lover. One day a spider's web fell into her lap, and the idea came to her mind to copy it in thread. This she did, her lover helping her by fastening sticks of wood to the various threads to keep them straight. She was able to make an exact copy in this way, which met with such favor from the ladies of Bruges that her purse was filled with gold. Fortunately the Virgin absolved her from her vow.

Bobbin lace. We are told that bobbin lace was first made at Annaberg (Saxony) by Barbara Uttman, in 1561. She established a school to teach the art to the peasant women, and bobbin lace making spread rapidly throughout the coun-

try. Bobbin lace is made with many threads, which are twisted and plaited together. Each of the threads is attached to a separate bobbin, and a pillow is used as a support for the lace while in the process of construction. On the pillow is fastened a parchment pattern, and into it many pins are stuck which hold the various threads in position until they can be twisted and plaited into their permanent places. Bobbin lace is often called pillow lace for this reason. Because of the method of its construction bobbin lace is capable of the most beautiful meshes and intricate figures that can be produced in fabrics. Some of the best-known varieties of bobbin lace are Valenciennes, Maltese, Chantilly, Mechlin, Brussels, and Honiton.

Publishers' Photo Service, Inc.

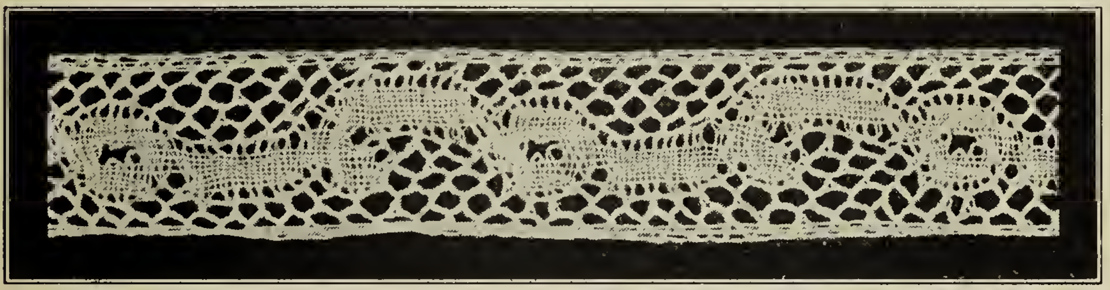
A BOBBIN-LACE MAKER IN SWITZERLAND

Note the many bobbins used

Needle-point lace. Just how the making of needle-point lace was discovered is not known, but the art was taken up by the nuns and peasant women, and needle-point lace quickly assumed priceless values. This lace is made by the use of a needle and a single thread, and the stitch is always a loop (or buttonhole) stitch. The best-known kinds of

needle-point lace are Venetian raised point (or *gros point de Venise*), Venetian flat point (or *point plat de Venise*), grounded Venetian point (or *point de Venise à résau*), and rose point.

From Belgium and Italy lace making spread rapidly and developed to a high degree of perfection. The most beautiful laces ever produced were made during the sixteenth and seventeenth centuries. Some of these old laces are now preserved in museums and are so elaborate in design and perfect in workmanship as to hold one spellbound with



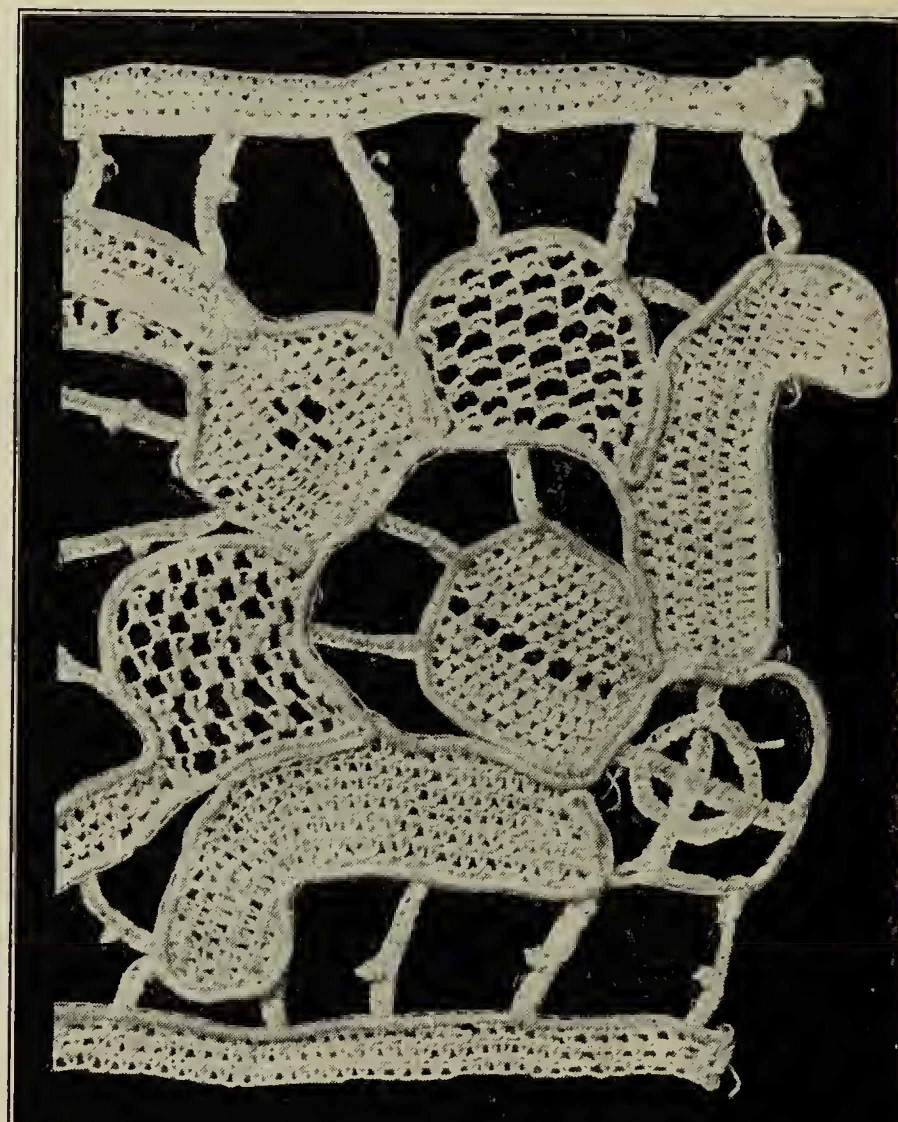
INSERTION OF BOBBIN, OR PILLOW, LACE

admiration. When linen thread was used, lace makers often had to work in damp cellars to prevent their gossamer-like strands from breaking as they worked.

In the middle of the seventeenth century there was a great increase in lace making, owing to the scattering of French refugees through England and Spain. At first the Italian and Flemish patterns were used by all the lace makers, but gradually each center or town developed its own patterns and styles, producing such laces as Alençon, Valenciennes, Honiton, Florentine, Chantilly, each with distinct characteristics of its own. These characteristics are carried out in the modern machine-made reproductions.

Invention of the lace machine. While England was not at all conspicuous in the art of making lace by hand, she was destined to be the first country to make lace by machinery. Along with the many inventions connected with the making

of woven and knitted cloth during the eighteenth century, it was only natural that the inventive genius among Englishmen should turn to constructing a machine for making lace.



NEEDLE-POINT VENETIAN LACE

Note the number and arrangement of stitches

This seemed the hardest problem of all, and history tells us that many lives and fortunes were ruined in the struggle.

1. *Hammond's attempt.* The first step toward the invention of a lace machine was when William Lee invented his stocking frame in 1589. Many years later, improvements were added to this machine by which knitted materials

could be shaped, ribbed, and ornamented with eyelets or openwork. The approach to lace making was drawing near. In 1768, it is said that a stocking-frame knitter of Nottingham, named Hammond, produced on a stocking machine the first figured lace web ever wrought by mechanical means. But this lace, while it was beautiful, had a mesh of looped, or knitted, stitches which would easily unravel, instead of a mesh of twisted and knotted threads such as were found in hand-made lace. Hammond's invention was only a step in the right direction, as a fast-meshed net was demanded, that should be made of firmly knotted, plaited, or twisted threads.

IN THE BEAUTIFUL DUCHESSE LACE THE TAPE SECTIONS ARE MADE WITH BOBBINS, THEN FASHIONED INTO A DESIGN WITH A NEEDLE

2. *Heathcoat's triumph.* The hand-made bobbinet mesh had from three to six equal sides and was durable as well as beautiful. To imitate perfectly this regular-sided mesh now absorbed the attention of many inventors. John Heathcoat, of Leicestershire, was the first to solve the problem of mechanically making the threads twist around each other and travel in three separate directions (vertically, diagonally, and toward each side) at the same time. Many other machines had made the *twist*, but none other had solved the problem of the *traverse* of the threads. Now a mesh could be

made which resembled perfectly the hexagonal mesh of the pillow net, and it was fast and durable. This bobbinet machine, invented in 1809, was one of the most intricate the world had ever seen, and it immediately became exceedingly popular. Heathcoat had performed a seeming miracle by his invention, and the results of his achievement are seen in the quantities of machine-made lace that flood the world today.

3. *Leavers's improvement.* In 1813 John Leavers of Nottingham (England) improved on the bobbinet machine, making one which still bears his name and which is in general use in England and France today. It will weave with a thread as fine as a hair, and so delicately is it adjusted that the breaking of one of these filmy strands will instantly stop the motion of the machine. The nets that it makes are beautiful in design, imitating various styles of expensive hand-made laces. Other inventors have increased the speed of the machine. Innumerable variations in size and shape of mesh and width, thickness, and pattern of lace can now be produced; but the principles that Heathcoat and Leavers combined in the lace machine have never been changed. Since the addition of the Jacquard system in 1837 the beauty and intricacy of machine-made lace has increased, until now we have so wonderful a product that in many instances it is impossible for any but an expert to distinguish the machine-made imitation from the hand-made original.

Lace making by machine. Lace machinery is very complex, but the fundamental principles are as follows: The warp threads are stretched perpendicularly on the machine, far enough apart for the bobbins to pass between. These tiny circular bobbins, carrying their own supply of thread, pass like pendulums between the warp threads, oscillating as they pass, and by this oscillation their threads become twisted with the warp threads as required by the pattern. If

the tension of the bobbin threads is tight and of the warp threads slack, the warps will be twisted on the bobbin threads; but if the warp threads are held tight and the bobbin threads slack, then the bobbin threads will be twisted on the warps. Combs compress the twistings, making them compact.

On the Leavers machine are made nets of all kinds,—Cluny, torchon, shadow lace, Valenciennes, etc. When narrow, the laces are made in strips fastened together by draw-strings, sometimes as many as sixty strips being made at one time.

The embroidery machine. Because of the great expense involved in setting up the machine to weave a pattern in the net (it frequently takes two men working a week to thread the machine) it was felt that embroidery could be done upon a net much cheaper and the effect would be substantially the same. In 1880 the first successful machine for this work was made,—a hand-embroidery machine. This has since been improved, and a power machine called the Schiffli machine now does the work at a greatly increased rate of speed. The action of the Schiffli machine is similar to that of a sewing machine. The material, nine yards or more of net or cloth upon which the embroidery is to be done, is tightly stretched in an upright position in the center of the machine. The needles which do the embroidering are arranged in straight rows, with from 150 to 300 needles in each row, according to the pattern, all pointing toward the cloth and extending from end to end of the nine yards. The needles are double-pointed and threaded in the center, and as they move forward they repeat the pattern simultaneously along the entire length of the material. So wonderful are these machines that absolute reproductions of hand embroidery are made, the stitches running up or down, sideways or diagonal, just as in handwork. The only difference that one can detect between

hand-made and good machine-made embroidery is that in the latter the pattern is less clearly defined than in handwork.

The invention of the embroidery machine led to the discovery of the principle of embroidering on a material which can afterward be removed by chemical action. This is called the burnt-out process and is most interesting. If the lace to be made is of cotton or linen, it is embroidered on silk; if it is of silk, it is done on cotton. Then the entire piece is dipped in a chemical which will destroy the foundation without injuring the embroidery, as the chemical acting upon the vegetable fibers will not act upon the animal ones, and vice versa. This method is much cheaper than operating the Leavers machine and is therefore used for the inexpensive laces. All imitation Venise lace and much filet are made by this process, and many of the so-called novelty and oriental laces.

Finishing processes of lace. The finishing processes in laces are both interesting and important. After coming from the machine all lace is carefully examined and, if necessary, mended; then all the extra threads are clipped off by hand. Most laces are bleached. A few, however, are left cream-colored in imitation of the real. After having been put through a hot mixture of gum and starch, lace is run between revolving rollers. This extends the mesh to the proper size and keeps it there. From these rollers the lace is transferred to the drying frames, which hold it to the proper width while revolving fans dry it. After again being run through hot rollers it is taken to the packing room to be cut and rolled. The burnt-out laces have, of course, the extra chemical processes.

Lace-making countries. Nearly all machine-made laces, as well as hand-made, are imported. Calais (France) furnishes the finest and most delicate reproductions. Nottingham (England) furnishes most of the nets and uses the Leavers machine in all its laces. It leads in making lace curtains and

is a close rival of Calais in the manufacture of Chantilly, Cluny, Valenciennes, Bruges, and torchon laces. St. Gall (Switzerland) and Plauen (Germany) produce most of the novelty and Oriental laces, as they use both the Leavers machine and the burnt-out method.

Lace is made in a few places in this country. An attempt was made in 1910 to stimulate the industry by a tariff law which allowed the Leavers machine to be imported free of charge. Trained lace makers were not "imported" at the same time, however, and as a result the manufacturing was greatly hindered. In New York web, or all-over, lace is made; Rhode Island has several lace factories, as have Pennsylvania, Ohio, and New Jersey. Zion City (Illinois) makes narrow laces, and lace curtains are made in several states.

Extended use of lace. Because of their artistic ability to conceive the beautiful designs and their tireless industry in executing them, the early lace makers have left wonderful models in lace which can now be reproduced and sold at a small price. Instead of being confined to royalty this ornamental fabric can be used by nearly everyone for trimming the clothing or decorating the home. To a certain extent fashion dictates the amount and kind of lace that shall be used, but to a greater degree than with other textile materials the taste or experience of the user decides the kind of lace she employs.

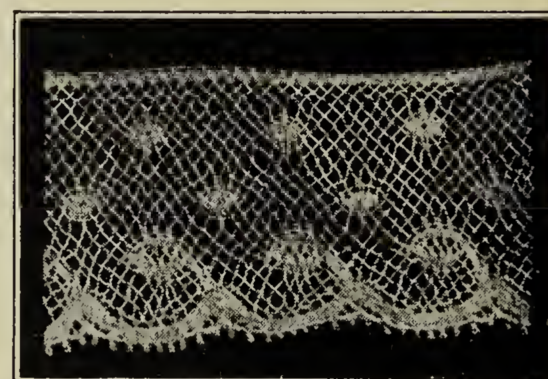
Imitation bobbin laces. 1. *Val.*[1] Probably the most popular of all laces, whether made by hand or by machine, is Valenciennes (Val). We find it on neckwear, blouses, gowns, children's wear, and all kinds of lingerie, whether of silk or of cotton. It comes in a great variety of widths and designs, its beauty, adaptability, and durability causing it to overrule the dictates of fashion and continue to be a staple kind

[1] While this lace is properly known as Valenciennes lace, it is so generally known by the shortened form *Val* that this term is in general use.

of lace used at all times. Its history has attached to Valenciennes lace the names of many different countries, as German Val, French Val, Normandy Val, Italian Val, etc. As

GERMAN, OR DOUBLE-THREAD, VAL

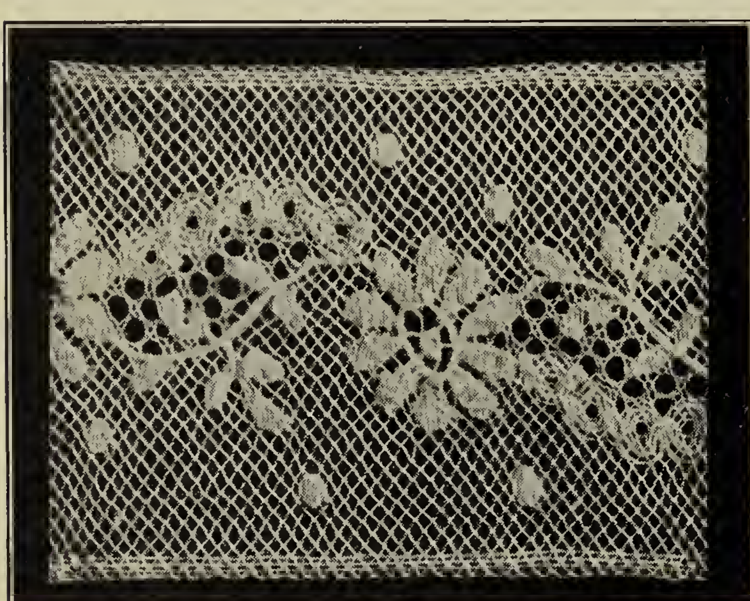
Made in the United States



FRENCH VAL

Made in the United States

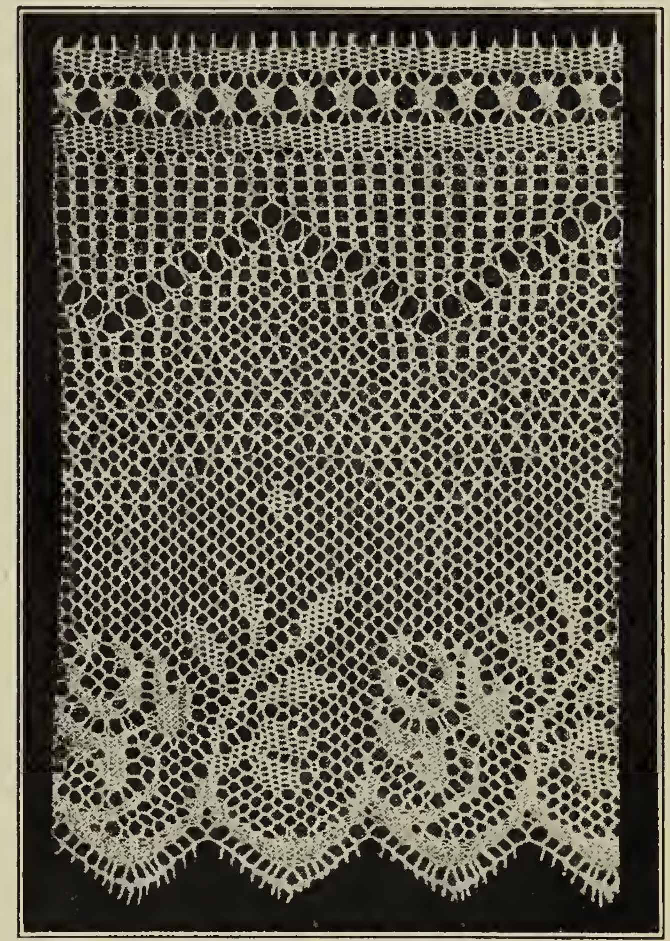
a matter of fact all machine Val laces are made in France, England, and the United States, Germany producing none. The mesh of French Val is diamond-shaped and made with very fine thread, while that of the so-called German, or double-thread, Val (made either in England or in the United States) is hexagonal, made with a heavier thread. Filet Val has a square mesh. French Val is not made in Valenciennes, as one would suppose, nor in Normandy, but in Calais. English Val is made in Nottingham, and the largest plant for making Val in the United States is at Zion City, Illinois. Some Val



MECHLIN

laces have a large, flat pattern and are called Plat Val, and others have the pattern outlined by a heavy thread. All the machine-made Val laces are reproductions of the bobbin laces first made in Belgium and afterward made in different parts of Europe, taking on the characteristics and the names of their new locations.

2. *Mechlin.* Mechlin lace resembles Valenciennes but is made with a finer thread and is somewhat lighter and filmier in appearance.



SHADOW

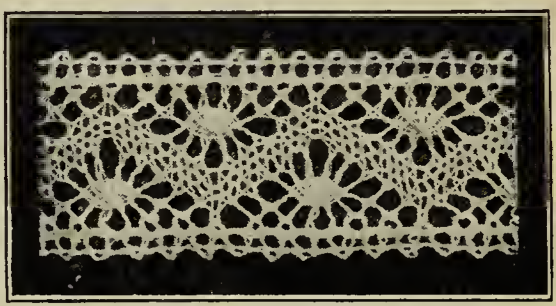
3. *Shadow.* Shadow lace, made of cotton, is a filmy descendant of the old Chantilly, a lace developed in Spain and made of silk.

4. *Torchon.* Another type of bobbin lace that is most successfully imitated is best represented by our torchon laces. Hand-made torchon lace is a firm, closely plaited lace made with coarser yarns than those used for Valenciennes. It is simple in construction and is made by the peasants in nearly all the European countries. It is often called beggar's lace. The imitation torchons are strong, enduring laces, coming in many widths and a great variety of designs. Medici lace is similar to torchon.

5. *Cluny.* Cluny is a bold, striking bobbin lace made with strong, rather coarse linen thread, the wheel or paddle and

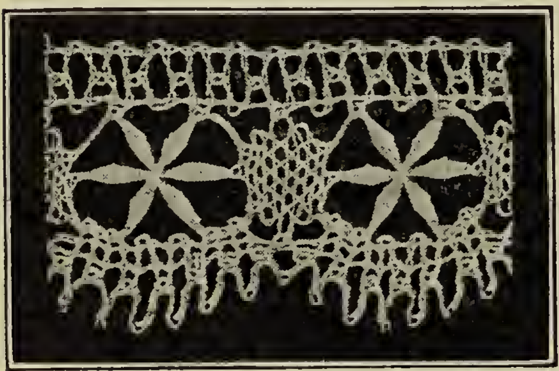
the star being characteristic motifs in the design. It was first made in Cluny, Flanders. Machine-made Cluny is usually made from cotton thread, two sizes being employed, while in real Cluny only one size of thread is used. Cluny

REAL TORCHON

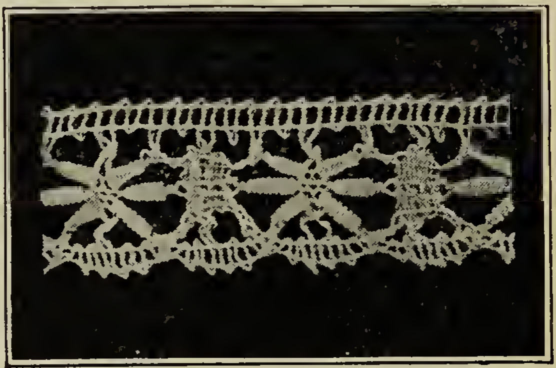


IMITATION TORCHON

lace is more popular for decorative purposes than for the trimming of clothes, though narrow Cluny is frequently used for clothing. Barmen (Germany) leads all other countries in quality of machine-made torchon and Cluny, but England and the United States produce them in larger quantities.



REAL CLUNY

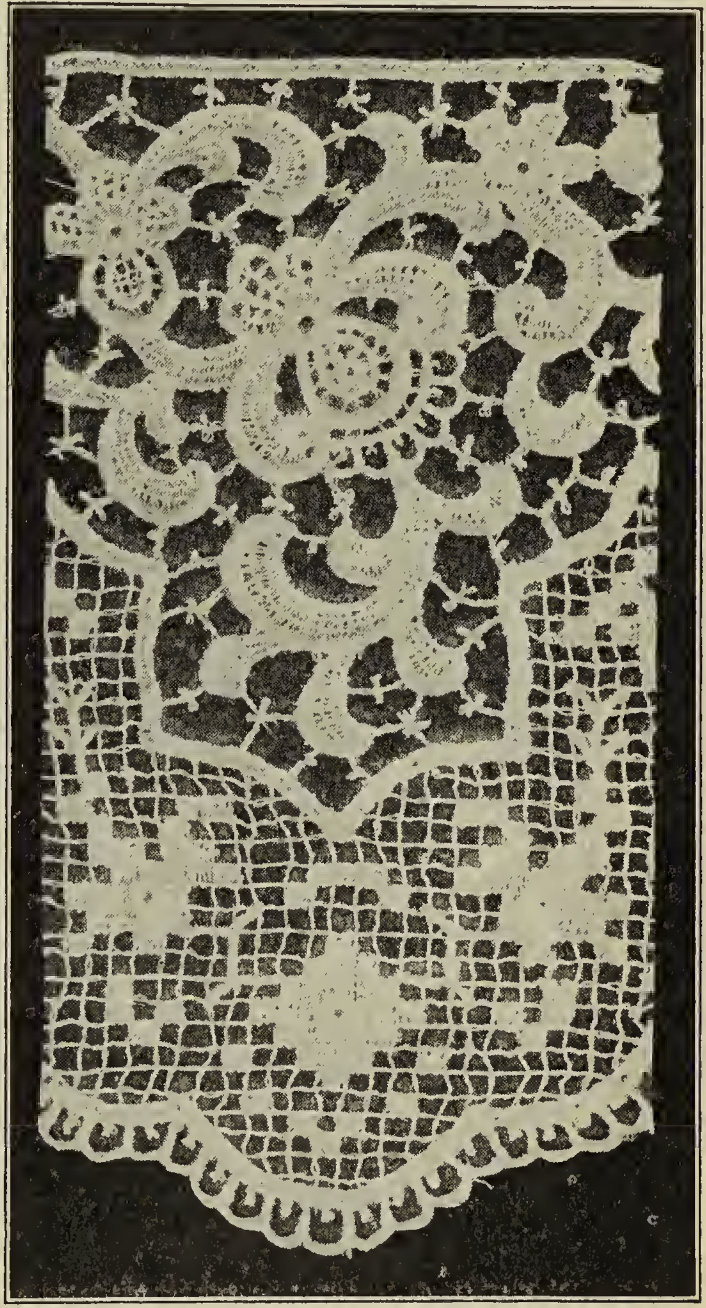


IMITATION CLUNY

6. *Maltese.* Real Maltese lace is a bobbin lace, usually of silk. It is characterized by the Maltese cross and by seedlike dots called *mosca.* Imitation Maltese is made of cotton.

Imitation needle-point laces. Needle-point laces are, however, usually more beautiful in design and more difficult in execution than bobbin laces. Needle-point laces are the aristocrats of the lace world.

1. *Venise.* One of the best known and imitated of these laces is the Venetian point, or Venise. There are many varieties of the real Venetian point, from the heavy kinds made with rather coarse, strong threads, and so containing heavy cords or ridges, to the firm but filmy laces with thread so fine that one can hardly discover the individual stitches. Until the Schiffli machine and the burnt-out process were invented there was no successful way of making needle-point lace by machine. Now the Schiffli machine embroiders in cotton upon a thin silk background any pattern found in Venetian lace. The whole piece is then put into a chemical bath which eats or burns out the silk background, leaving the embroidered pattern, however delicate, standing alone.

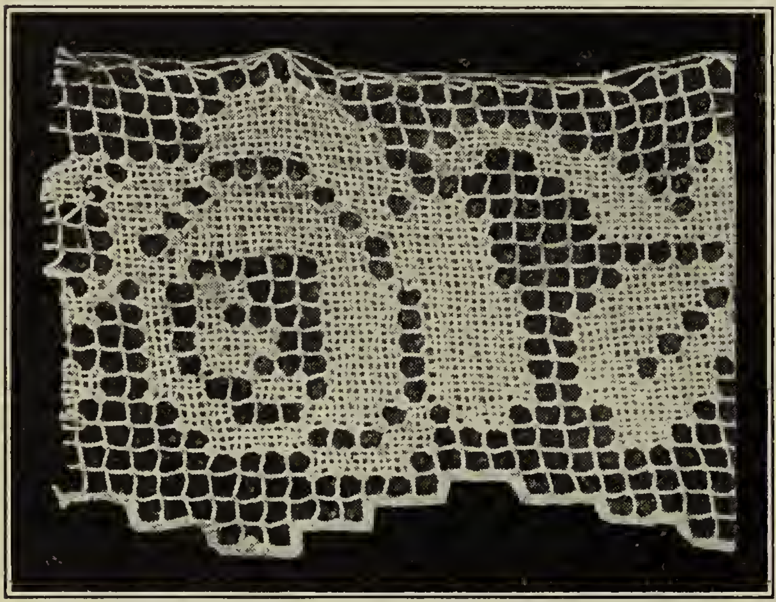


A COMBINATION OF IMITATION VENISE AND FILET, THE BURNT-OUT PROCESS BEING USED FOR BOTH

2. *Oriental and novelty laces.* This same wonderful machine embroiders on net, giving us the Oriental, or net-top,

laces. Sometimes the burnt-out process is also used with these net-top laces. Switzerland does the most wonderful work with the Schiffli machine.

3. *Filet.* Real filet is a strong, flat, beautiful lace of square mesh, the pattern being woven or darned into the mesh. This lace is most successfully imitated by the Leavers machine, though a low-priced quality of filet is produced by the burnt-out process.



REAL FILET

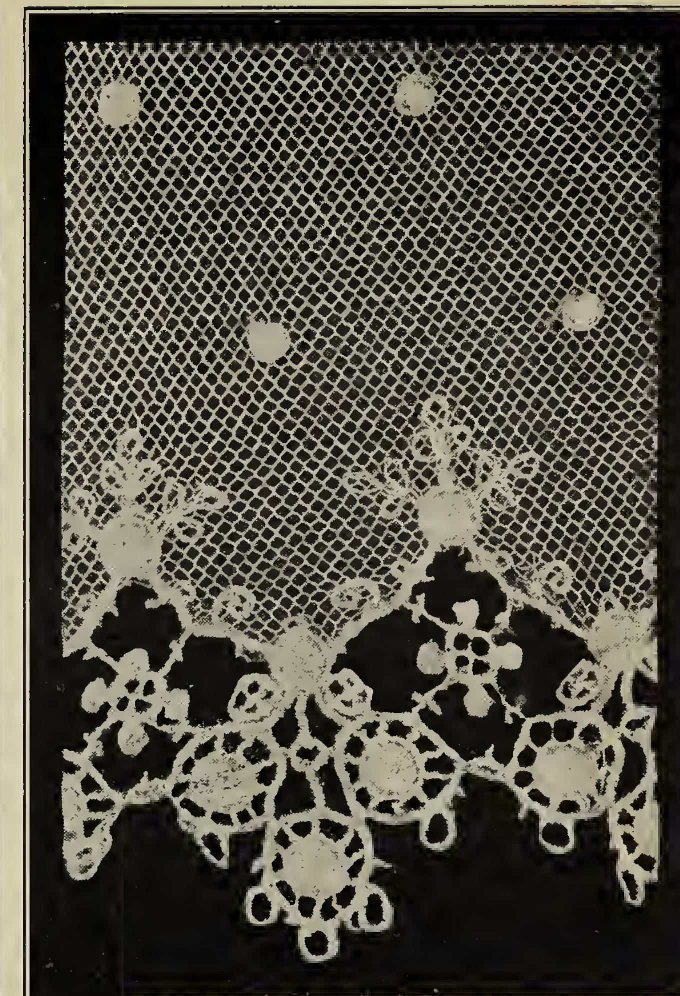
Other types of laces. Other real laces of somewhat minor importance are made with a needle, a crochet hook, or a shuttle. The narrow Armenian edge, made with a needle, is popular for handkerchiefs and infants' clothes. Tatting, done with a shuttle, is a strong lace which is well imitated by the lace machine. Of the crocheted laces Irish and baby Irish crochet are the most important. They are thick, strong laces frequently containing the rose and shamrock motifs. There are good machine imitations of Irish and baby Irish lace.

ARMENIAN LACE

Significance of a piece of lace. It is not feasible at this time to attempt the description of the great variety of nets used for veiling and millinery purposes, nor of the almost limitless

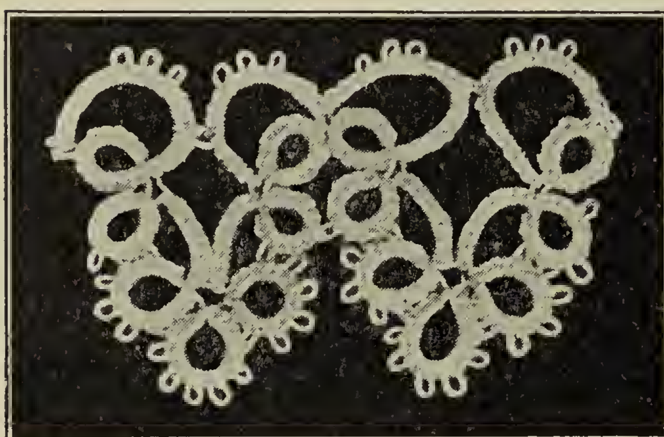
REAL MALTESE

BABY IRISH (HAND-MADE)



ORIENTAL LACE, WITH BURNT-OUT BORDER

kinds and combinations of nets, tapes, and laces used in curtains. These articles, like the laces we have described, contain reproductions and adaptations of old hand-made laces and may now be found in our stores and homes only because of the successful struggles of the lace-machine inventors. Any strip of lace, therefore, whether it costs five cents or fifty dollars a yard, is something more than a pretty piece of decoration. Hand-made lace is one of the most attractive illustrations of woman's genius and industry, and machine-made lace illustrates one of the great achievements of the human race.



TATTING (HAND-MADE)

QUESTIONS AND ASSIGNMENTS

1. Collect samples of lace and identify them. Mount on cards and give information, such as kind, width, price, use, place of manufacture, a reproduction of what. In what other widths does the lace come?

2. What kinds of lace are used for trimming dresses? What kind is most practical for underwear?

3. Visit a lingerie department and an infants' department in some store and find out the kinds of lace most used on the merchandise in those departments.

4. What kinds of lace are used for blouses and gowns? for household decorations?

5. Compare the prices of several kinds of *real* lace with the prices of their imitations. Why are people willing to pay this difference in price?

6. Visit your museum and inspect the specimens of lace preserved there. Why do these laces merit a place in the museum?

7. Try to find in a machine-made lace an exact reproduction of the design in a hand-made lace. Has the design a name? What is it? In what kinds of lace are such reproductions most easily found?

8. Give the names of lace manufacturers in the United States. Where are they located?

9. Find out the names of the different nets used in the veiling department of any store.

10. Write a paper on the study of some form of lace (as veilings, lace curtains, Valenciennes laces, etc.), illustrating it with samples or pictures of the different styles of lace and net.

11. Interesting articles on lace and lace making occasionally appear in our current magazines and newspapers. Watch for such articles and give a review to the class of those you read.

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See page 369.

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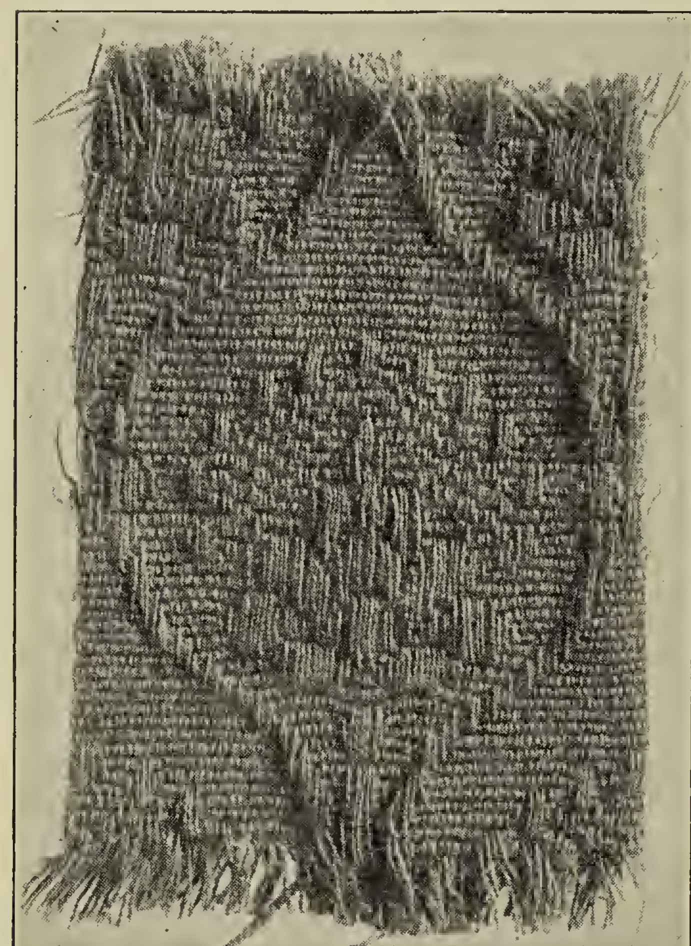
CHAPTER VI

THE MAKING OF CLOTH: YARNS AND THE SPINNING PROCESS

We now begin to see that the value of fabrics and the purposes for which they are to be used depend in a great degree on the way in which they are made, that is, the kind of weave used in woven cloth, the kind of stitch employed in knitted goods, and the method followed in producing lace; but we may not yet realize how dependent the character of these three types of materials is upon the kind of yarn used in their construction.

Differences between yarn and thread. Yarn, which is a continuous strand of any kind of twisted fibers, much resembles thread in appearance, and the yarns of which a fabric is woven or knitted are often spoken of as the threads of the cloth. Yarn, however, differs from thread in several important respects. Thread is the name of a smoothly finished, tightly twisted strand of cotton, silk, or linen, composed of several separately twisted strands called ply, and is used with a needle for sewing, either by hand or by machine. It is also used in making lace. Thread must be smooth and uniform in size throughout its length, so as to run through the eye of the needle; it must be singed and well sized or starched, so that the ends of the fibers will not fuzz up as the strand is drawn in and out of the cloth; and it must be strong to bear the strain that always comes upon the joint, or seam, when two pieces of fabric are joined together. Yarn is, in general, less tightly twisted than thread, is often of only one

ply, or strand, and is usually unfinished, or much less sized and singed than thread. Lisle yarn, which is a hard-twisted, 2-ply, singed yarn, most closely resembles thread, and lisle hose are often spoken of as *lisle-thread* hose. We never hear of woolen or worsted thread, but always of woolen or worsted yarns.



UPHOLSTERY REP

Influence of yarns upon the appearance of cloth. As many varieties of weaves and stitches are used in making different kinds of cloth, so many varieties of yarn are employed for emphasizing in the weave or stitch the characteristics of the cloth to be made. Take this piece of figured upholstery rep, for example. The Jacquard weave has produced an attractive conventional design, but notice how the prominence of the figures has been increased by the combination of a heavy filling yarn with fine warp yarns. Another combination of fine, tightly twisted warp yarns with coarse, loosely twisted filling yarns produces the soft, woolly material so much used for bathrobes and baby blankets. Since this is a kind of double cloth, only the filling yarns show on either the face or the back of the goods, while the concealed warp yarns give to the cloth the necessary firmness and strength.

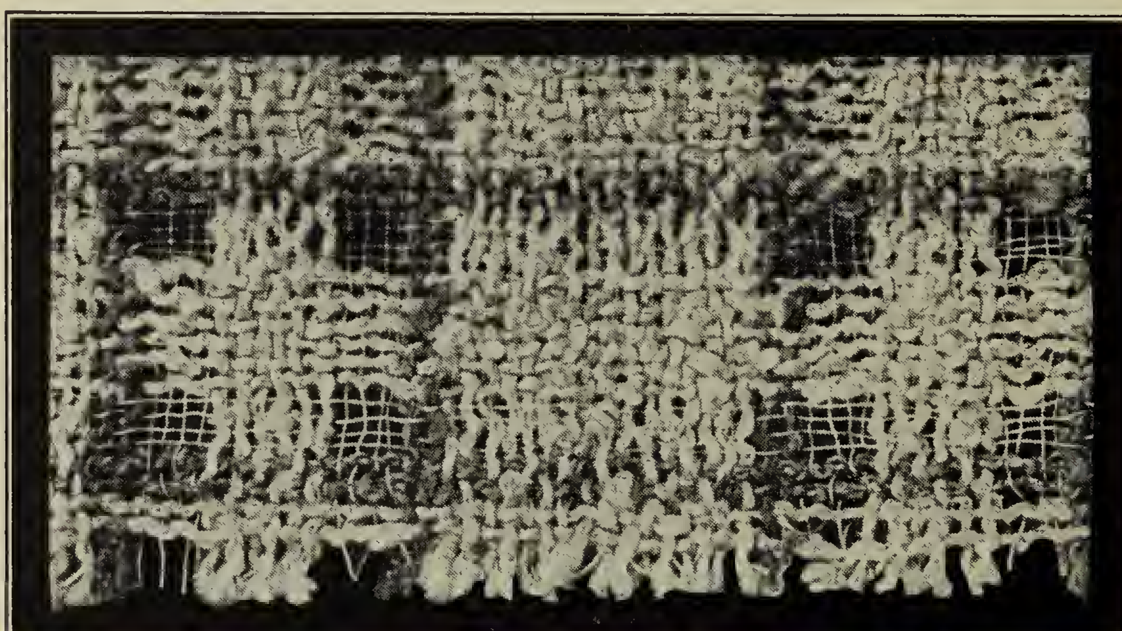
Examine Japanese crêpe. It has the appearance of an unusual weave, but we find that only the simple weave has been employed. The pebbly effect is produced by a combination of much-twisted and slightly twisted yarns. The slightly twisted yarns form the warp and are held tight, while the kinky ones form the filling and are left loose. Georgette crêpe has a plainly discernible weave but a crinkly appearance. Here both warp and filling yarns are tightly twisted, some yarns being twisted to the right and some to the left, drawing and kinking in different directions.

Look at pieces of tweed and wool voile. You notice that the tweed is very rough and the simple weave is somewhat obscured by the rough yarns. In the voile the weave is clearly seen, for smooth, hard-twisted yarns are used.

In surgeon's, or hospital, gauze the yarns are soft, with the fuzzy ends of the fibers standing out, making the cloth absorbent. A scrim having the same weave is made of yarns from which these fuzzy ends have been removed. Crash is woven from uneven yarns containing irregular thick and thin places, while duck and beach cloth, of the same weave and count, are made from even, uniform yarns. The yarns in linen damask are flat, while in cotton canvas they are round. The ribs in poplin, bengaline, and other ribbed materials, the ridges in striped and crossbar dimity, the rough effect of ratiné, the two-toned effect of chambray and shot silk, and the speckled effect of denim and covert cloth are produced by the size, character, or color of the yarns employed rather than by any special kind of weave.

The well-known distinctions between woolens and worsteds which govern their use and wearing properties rest upon the kind of yarns used, and any manufacturer of knitted goods will tell you that the quality and character of his products depend almost entirely upon the quality and character of the yarn of which they are made.

Common varieties of yarns. Have you ever noticed the varieties of yarn used in making our different kinds of cloth? Think of the ranges in size from those tiny yarns, almost like the strands in a spider's web, that are used in our finest silks and sheerest linens, to the large yarns, almost cords or ropes, used in our coarse canvas, our cleaning cloths, our mops, and our heavy sweaters. In regard to twist, there are yarns



FANCY RATINÉ

Note the different sizes of yarn

twisted so much as to kink on all possible occasions. This is the reason why crêpe de chine and other silk crêpes curl and apparently shrink so much when washed. The tightly twisted yarns kink when wet and remain kinked until they are straightened out again by the ironing process. There are yarns with almost no twist in them, like those in Canton linen and Baronette satin. Some yarns are so smooth and clear that they show no fuzzy ends along their course. Those used for organdies, voiles, and good hosiery are of this kind. Other yarns are made so that the ends of the fibers will stick out all over them, as those used in cheviots and rough serges.

There are yarns made of one strand of twisted fibers ("singles" they are called), such as are used in weaving chiffons, and there are yarns that contain 3, 4, 5 or even 12 singles twisted together, which are used in making heavy duck and canvas.

Novelty yarns. There are also a large number of novelty yarns made of special combinations of materials and by special methods of construction. They are best described in a letter written to the author by Mr. J. R. Montgomery of Windsor Locks, Connecticut, a manufacturer of novelty and other yarns:

The term *novelty yarn* is used to cover all yarns which are used to give an unusual or novel effect in fabrics and in trimmings. If we accept this definition it will be readily seen that the field occupied by the product is a large one and the material used infinite, and that its manufacture covers a period that reaches from a very ancient time to the present day.

The industry in the United States dates from about the year 1876, when the manufacturing of this yarn was commenced by the J. R. Montgomery Company at Windsor Locks, Connecticut. The first in the line was an imitation of a French manufacture called *bourette* yarn, a name which has clung to it more or less tenaciously ever since, although the American manufacturers know it as "worsted knotted yarn." This same effect had been produced in wool yarn and used in shawls in Scotland some years previously, but not imported into this country.

There was a sudden demand in the United States for a yarn to use in goods to imitate ladies' dress goods that were being imported from France. After repeated attempts we succeeded in producing a yarn which, by reason of the necessity of the cloth manufacturers rather than its own merit, was accepted and used very largely. After a time we improved our machinery and produced this yarn very perfectly. It still has its periods of demand and use.

From this first effect there have developed a very great variety of novelty yarns, including nub yarns, wool and cotton flake yarns, mohair loop yarns, and worsted and silk spiral yarns.

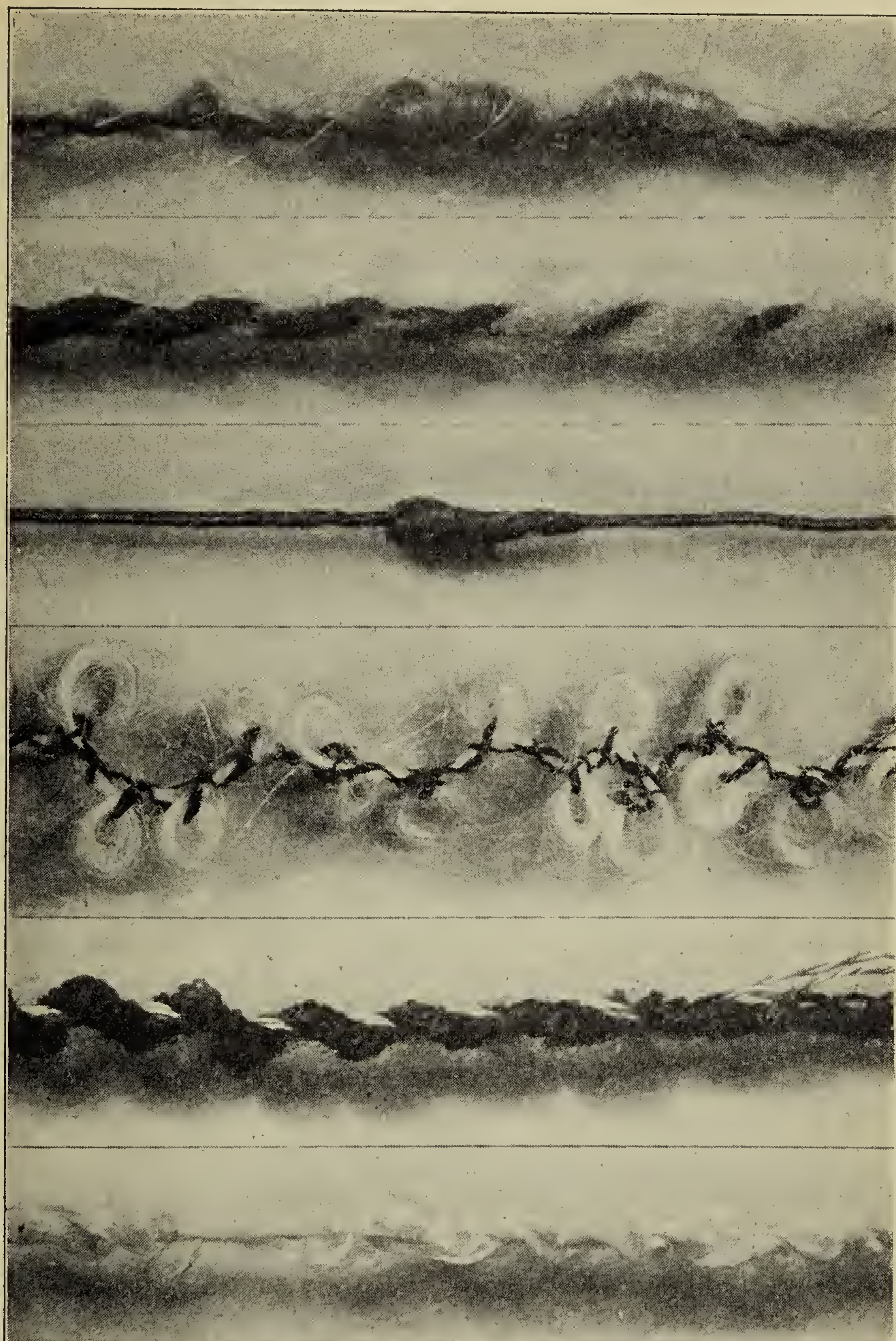
Probably the most sensational and popular feature ever introduced in the woolen-goods market in the United States was the importation almost simultaneously, from England, Germany, and France, in 1883, of goods in which a yarn appeared upon the surface in the shape of rings or loops made of mohair. The American manufacturers were wholly unable to make the goods, from lack of the proper machinery to produce the loop effect required. The J. R. Montgomery Company designed and built machines to produce this peculiar yarn; the demand for it at the time was very great and it has had its seasons frequently since the first sensational run of these goods.

In 1886 we commenced the manufacture of metal, or tinsel, yarns. Under this head are included all yarns or threads in which metal is used as a component part to get the effect desired. Although these yarns were first successfully produced in the United States in 1886, it is interesting to know that yarns of a similar character have been made for centuries. Indian and Chinese stuffs were from time immemorial woven with gold. The Israelites wove gold with their colored woolens for use in their sanctuaries. They probably brought the art from Egypt. They beat the gold into thin sheets and stripped it into narrow ribbons and wound it spirally around a silk filament for the base.

In 1360 A.D., Anthony Fournier, a mechanic of Nuremberg, invented a machine for the purpose of flattening wire, and was given a patent for the exclusive use of the idea for fifteen years, which was afterwards extended for fifteen years more. This was another way of getting the same product that the ancients obtained by pounding gold into sheets and then cutting it into strips. Fournier's idea was introduced into England two hundred years later. Up to the year 1680 A.D. pure gold had been used to make gold thread. At about that time the plating of copper with silver and with gold began, and this is in every way the tinsel of today. Metal threads were first produced successfully in this country in 1890.

Numerous samples of goods containing gold thread (from the fourteenth to the sixteenth century) may be seen in the Boston Museum of Fine Arts and other museums.

For the past ten years few absolutely new kinds of yarns have appeared, though many have been designed which give new effects but are found, upon analysis, to belong to some of the classes already



TYPES OF NOVELTY YARNS

1, nub yarn; 2, flake yarn; 3, knot yarn; 4, loop yarn; 5, 6, spiral yarn

developed and capable of being made on machinery already constructed. Also combinations of two or more varieties are common.

Some idea of the multiplicity of designs may be had by consideration of the fact that novelty-yarn manufacturers in this country are producing today over 15,000 designs of yarns, any one of which they may be called upon to produce at any time. These are used in producing novelty effects in cotton, wool, worsted, silk, and mohair goods in various designs.

Although we have placed the date of the commencement of the manufacture of novelty yarns in the United States about the year 1876, it was not until some years later that designers began to look upon them as a factor to be considered in producing goods for our market. Today they are recognized as a valuable addition to their facilities. We believe the American manufacturer is today able to produce any yarn that has been made abroad to give the desired novelty effect, and that the time is not far distant when the American designer, having at his command such facilities as are afforded him, not only by the novelty-yarn manufacturer but by the weaver, the dyer, the mercerizer, the printer, and the finisher, will be able to rival any fabric made abroad.

The spinning process. Let us make some yarn from a tuft of cotton fiber. The process of making raw material into yarn is called spinning. What operations do you perform as you spin these short fibers into a continuous strand? Just as in the weaving of cloth, regardless of how elaborate the weave or complicated the process, there are three distinct fundamental operations, so in the spinning of yarn there are also three distinct fundamental operations. They are the *drawing out* of the raw material into something resembling a strand, *twisting* it to bind the fibers together and give strength to the strand, and *winding* it in some manner so that the strand can grow as long as desired without becoming entangled. The fundamental steps in spinning are therefore very simple,—drawing, twisting, and winding. In the present day the making of yarn in a mill is so complicated, each fundamental operation is so divided, and such

a number and variety of machines are used in spinning, that an observer easily becomes confused when watching the spinning process. Yarns in the different stages of manufacture have many names. Some of the most common are *lap*, *web*, *sliver*, *slubbing*, *drawing*, and *roving*. Each of these different stages of yarn is made by a different machine, and there are many kinds of drawing, doubling, twisting, and winding machines.

Yarn counts. When yarn is made of only one strand of twisted fibers, it is called a *single* (s), and when it is made by twisting 2, 3, or more singles together it is called 2-ply, 3-ply, etc. Sewing cotton is usually 3-ply, while some yarns or heavy cords run as high as 36-ply. As cloth must be woven exactly to specifications (so many picks and ends to an inch, so many ounces to the yard), yarn must be spun exactly to specifications. There must be so many yards of yarn produced from a pound of raw material. This is called the *count* of the yarn and is the measurement of its size. Yarn counts are different in different raw materials. In worsted yarn one count means that a strand of yarn 560 yards long has been made from one pound of wool. This yarn is called No. 1s (single strand) and is very coarse. No. 8s yarn means that eight times that length, or 4480 yards of yarn, has been made from one pound of wool. Nos. 30s to 40s are coarse and Nos. 60s to 100s are fine, No. 60s being the standard size in worsted yarn. In cotton a No. 1s yarn means that from one pound of cotton 840 yards of yarn have been made. Cotton yarns from No. 1s to No. 8s are very coarse and are used for lamp-wicks, cordage, etc. No. 60 sewing cotton, 3-ply single strand, is made of three 60s and is worked out thus:

$$\begin{array}{r} 840 \\ \underline{60} \\ 3\overline{)\,50400} \\ \hline 16800 \end{array}$$

This shows that 50,400 yards of single-strand yarn, or 16,800 yards of 3-ply thread, have been made from one pound of raw cotton. In the better qualities of sewing cotton each ply is made of two strands, each of which is spun twice as fine as the number of the thread. For instance, in No. 60 spool cotton each strand is spun to 120s. Sometimes cotton yarn is so fine that its count is 240s. This is the finest yarn for weaving met with in commerce. That means that 240 × 840 yards, or 201,000 yards, of yarn have been spun from one pound of cotton. This amount reduced to feet means a strand 604,800 feet, or (divided by 5280) nearly 113 miles, long. There is a record of a handkerchief made in England some years ago with No. 1000s cotton yarn. We can best appreciate the fineness of this yarn, perhaps, when we consider that a pound of cotton, when spun to a strand of this size, would reach nearly 500 miles. It is also said that, during a contest of experimental spinning, a pound of cotton was made into a yarn nearly 1000 miles long.

Other yarn specifications. 1. *Twist.* Not only must the size of the yarn answer every test, but the amount of twist must be exactly according to specification. In the filling yarns of most smooth silk fabrics there are only a few twists, from 3 to 6 per inch, while in the filling yarns of crêpe materials from 40 to 80 twists are required. The yarns for the great bulk of cotton materials contain from 20 to 30 twists per inch; worsted clothing yarns have about 15, and ramie, or grass cloth, yarns contain almost no twists.

2. *Strength.* Yarn specifications also state the amount of strain that a yarn must endure without breaking, and there are machines for accurately testing the strength of a yarn or cloth. This tensile strength, as it is called, is most important for certain classes of fabrics and depends to a great extent upon the quality of raw material used. In the production of airplane cotton by the United States during the World War

the strength of the fabric demanded was at least 80 pounds per inch each way, warp and filling.[1]

Preparation of raw material for spinning. 1. *Cleaning.* Before any raw material can be spun into yarn it must go through different processes in preparation for being drawn out and twisted. All raw material must be cleaned. Sometimes the cleaning is done with water, the fibers being soaked, boiled, or scoured. Flax, silk, and wool are cleaned by the use of water. Sometimes the cleaning is a dry process and the fibers are beaten, fanned, and dusted, as is the case with cotton. We shall learn these cleaning processes as we study each fiber.

2. *Carding.* All short fibers or fibers varying much in length must be untangled and somewhat straightened out in

[1] Excerpts from *Aëronautical Specification No. 13,* March 1, 1918, for *Mercerized-Cotton Airplane Fabric* (*Grade A*):

. . . .

Material.

3. The warp and filling yarns used in the manufacture of this fabric must be size 2/60, according to the English cotton-yarn numbers. A tolerance of plus or minus four (±4) will be allowed in the size of single yarns.
4. The length of the staple of the fabric must not be less than one and one-half (1½) inches.

Manufacture.

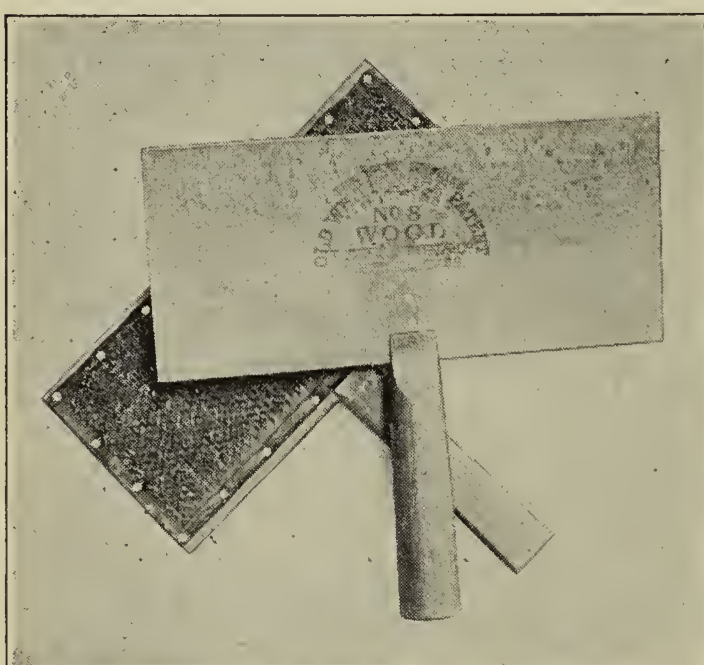
5. The yarn shall be combed (single or double) and shall be mercerized under tension.
6. It is recommended that the single yarn be given from 28 to 34 turns per inch of twist and that 16 turns per inch be used for twisting these yarns together. This procedure may be altered provided the fabric conforms to this specification in other respects.
7. There must be at least 80 threads and not more than 84 threads per inch in both warp and filling.
8. The weave shall be a plain weave.
9. The fabric must be uniform in structure and free from manufacturing imperfections.
10. The fabric, under normal moisture conditions, must not weigh more than 4.5 ounces per square yard.
11. The width must be 36 inches.

. . . .

Tests.

16. The average breaking load of the five (5) specimens cut in the direction of the warp and the average breaking load of the five (5) specimens cut in the direction of the filling . . . . . . must each be at least 80 pounds.

order to be spun with any degree of evenness. The process of untangling and straightening out textile fibers is called carding and was formerly done by hand. The raw material (usually wool) was put upon one of these cards, and the other was drawn over it, thus submitting the fibers to the action of all those little wire teeth. When this process had been repeated a number of times, the material would be an open, filmy sheet with no tangles remaining. This sheet could be gently rolled into a soft, light roll of uniform density and was then ready to be drawn out and twisted into yarn. This same principle of carding is now carried on in factories, but the wire teeth are placed in large sheets of rubber, which cover great rollers through which the raw material is run. These sheets, or strips, which sometimes contain as many as 950 wire teeth to the square inch, are called card clothing, and the modern carding machines are wonderful pieces of mechanism. All cotton, all wool, all tow (a part of flax), and all silk waste (a part of silk) must be carded before being spun, and for certain classes of goods the fibers are carded several times.

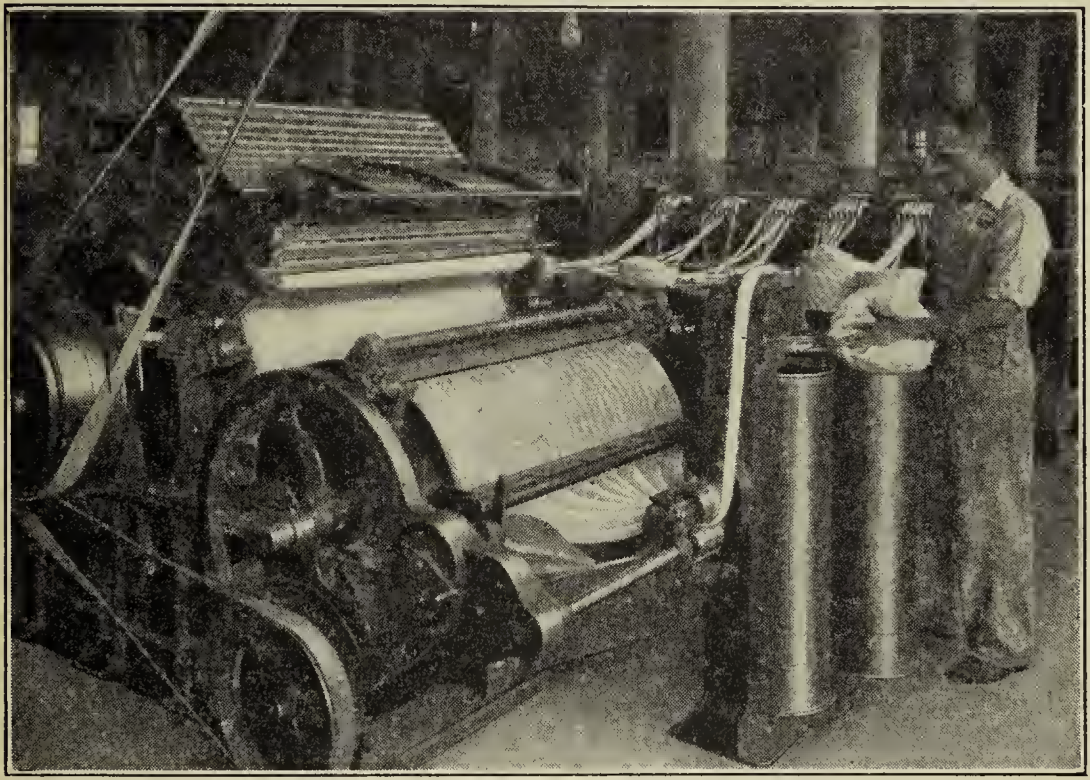


HAND CARDS

In obtaining the raw material for linen cloth many of the fibers are tangled and broken. These are called tow and must be carded and spun as has been described. The unbroken fibers, called line, are several feet in length and are not carded. Silk waste consists of

short and broken silk fibers, which are carded and spun, making spun silk. The reeled silk fiber, which is a continuous strand hundreds of yards long, is neither carded nor spun.

3. *Combing.* For some purposes wool, cotton, and silk waste are subjected, after carding, to a machine which throws out all the fibers below a given length, making the

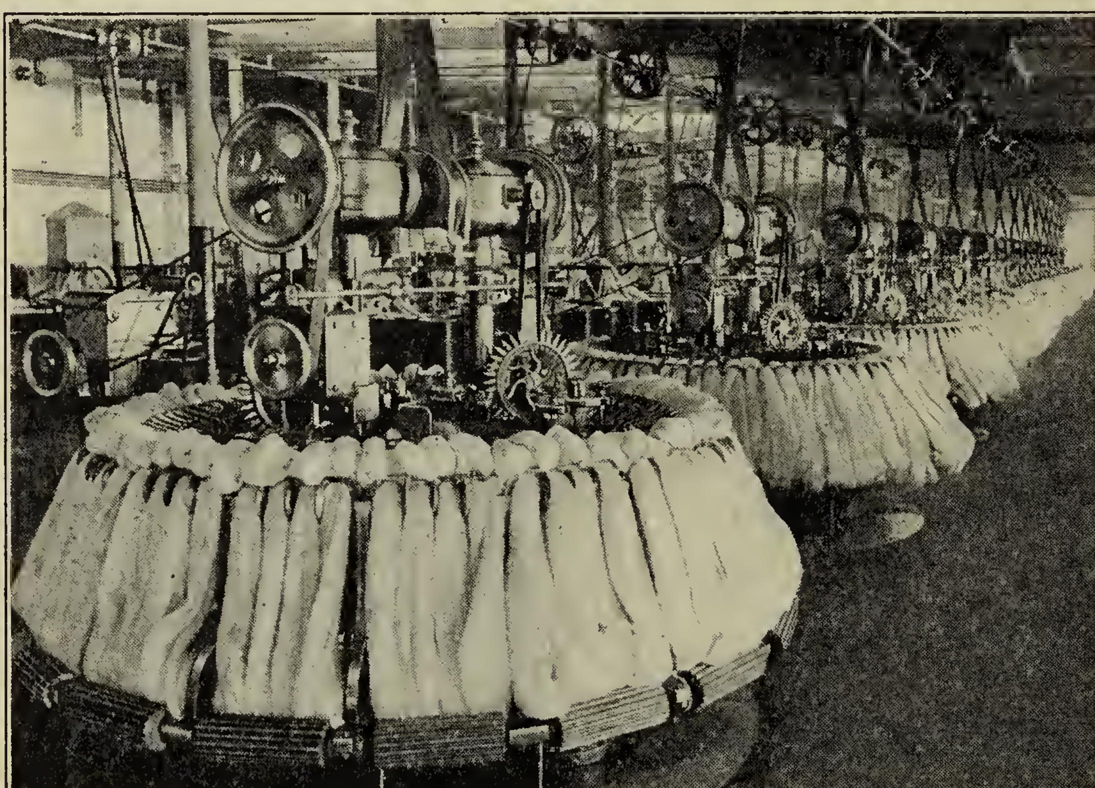


A MODERN CARDING MACHINE

Note the filmy sheet that is being condensed into the big, soft rope or sliver. Courtesy of Bemis Bros. Bag Co.

long fibers into a soft, smooth strand called a sliver. This machine is called a comb and the process is called combing. The Noble comb, which combs wool fibers, is a marvelous machine and seems almost human in its operation. The combing process is responsible for the great difference in character between woolen and worsted yarns and is one of the principal causes for the difference in appearance between woolen and worsted cloths. All worsted yarns are made from

combed wool fibers, which, because they are longer and lie parallel, can be spun into a smooth, compact, tightly twisted strand and woven into a firm material showing a clear weave and capable of enduring hard wear. Our smooth serges, voiles, and men's worsted suitings illustrate the use of these yarns. Woolen yarns, on the other hand, are spun from the



A WORSTED COMBING ROOM

Courtesy of Amoskeag Manufacturing Company

shorter fibers, which are only opened up and untangled by the carding process. They are never combed, as the character of woolen yarn would be destroyed if the fibers lay parallel. Consequently we have our flannels, tweeds, and broadcloths made of soft, fuzzy, loosely twisted yarns which obscure the weave and produce a warm, springy, and easily draped material. The short, tangled fibers that have been combed out lie in an unshaped mass. This mass is spoken of as noils and is run through the card, which again opens up and untangles

the individual fibers. Wool, silk, and cotton noils and flax tow are all carded and made into the kinds of yarns in which short fibers are not a disadvantage but, in some cases, may be a real necessity.

4. *Drawing and doubling.* The drawing out of the fiber in a modern mill is a truly marvelous sight. From the cards or combs the soft, untwisted slivers are put through drawing frames which decrease their size and increase their length. During this process several strands (3, 5, 6, or any number which entered a drawing machine separately) are united and delivered from it as one strand. Several of these strands may be united during the next drawing operation, and so on until the strand from the final drawing frame may be formed of fibers from hundreds of thousands of the original laps from the card. The combining of strands in this way is called doubling, and the whole operation is spoken of as drawing and doubling. This step in the spinning process allows the thorough mixing of different varieties of fibers into a blend of yarn that could be obtained in no other way. A well-known manufacturer of knitting yarns says: "For the spinning of some [of our] yarns it is necessary to have as many as 1,000,000 doublings." As the strand of yarn grows smaller during the drawing and doubling process, a slight twist is put in to hold the fibers together. The yarn in this stage is called roving and is ready for the spinning frame, whose principal work is to put in the final twist.

Warp and filling yarns. The evolution of spinning machinery, from the early hand process, where a spindle was used, through the period of spinning wheels to the present time, when many kinds of wonderful machines spin the vast quantities of yarn used for clothing the world, is described in the next chapter. But from the first, in spinning, two principles have persisted, controlling the two types of spinning machines always to be found. One principle is to make

a yarn that is firm, strong, hard-twisted, and relatively non-elastic. Such yarns are essential for warp, for sewing cotton, and for the filling and knitting yarns of certain types of materials. These yarns are usually spun on a machine where the three operations—drawing, twisting, and winding—form one continuous process. They are called ring spinning frames and were evolved from the old flax wheel that operated in this manner. The other principle is to make a soft, elastic, and less hard-twisted yarn that can be used for filling, for knitting and embroidery yarns, and for warp yarns of certain types of goods. Such yarns are usually spun on the mule spinning frame, which has an intermittent motion, the combined operation of drawing and twisting alternating with the single operation of winding. The mule is an evolution of the old wool wheel, which operated in the same way. The necessary characteristics for knitting yarns are softness, pliability, and strength, and nearly all yarns for knitted goods are mule spun. It is interesting also to know that the finest cotton yarns are always spun on the mule.

Evolution of the spinning industry. In the olden days, when all yarn was spun on wheels, many of the spinners were men. With the advent of machinery and the conquering of our new country, men turned to heavier work and women did the spinning. In our early Colonial days the women spun while the men hunted, fought Indians, and tilled the ground. In those days the word *spinster* suggested the occupation, not the state, of a woman. At the present time most of our large spinning frames are tended by women or girls, each one of whom can turn out a thousand times more yarn than one man working laboriously at his spinning wheel for the same length of time. The name *spindle*, which was applied to that first crude stick that was twirled in the hand to twist the yarn, still persists, and the size of a spinning mill is at the present time expressed by giving its number of spindles, as

DRAWING MACHINES WHERE THE SIX ENTERING STRANDS ARE DRAWN INTO ONE

Courtesy of Bemis Bros. Bag Co.

"a 20,000-spindle mill." Lowell, Lawrence, Fall River, and New Bedford, Massachusetts, are called spindle cities because of their large spinning mills. The output of these mills is tremendous and would fairly stagger one of the old hand spinners. A striking advertisement of a New England bank began with this statement in black italics, "*Twelve Million Spindles whirling Fiber into Yarn!*" showing the size of the spinning industry of New England. In other sections of the country, also, spinning has made rapid strides. The growth of the knitted-goods industry in Pennsylvania, New York, and the Middle West has so greatly increased the manufacture of yarn in those localities that the spinning industry is no longer concentrated in New England. This graphic description from a magazine published by a Wisconsin knitting company gives us some idea of the output of one of the present-day spinning mills:

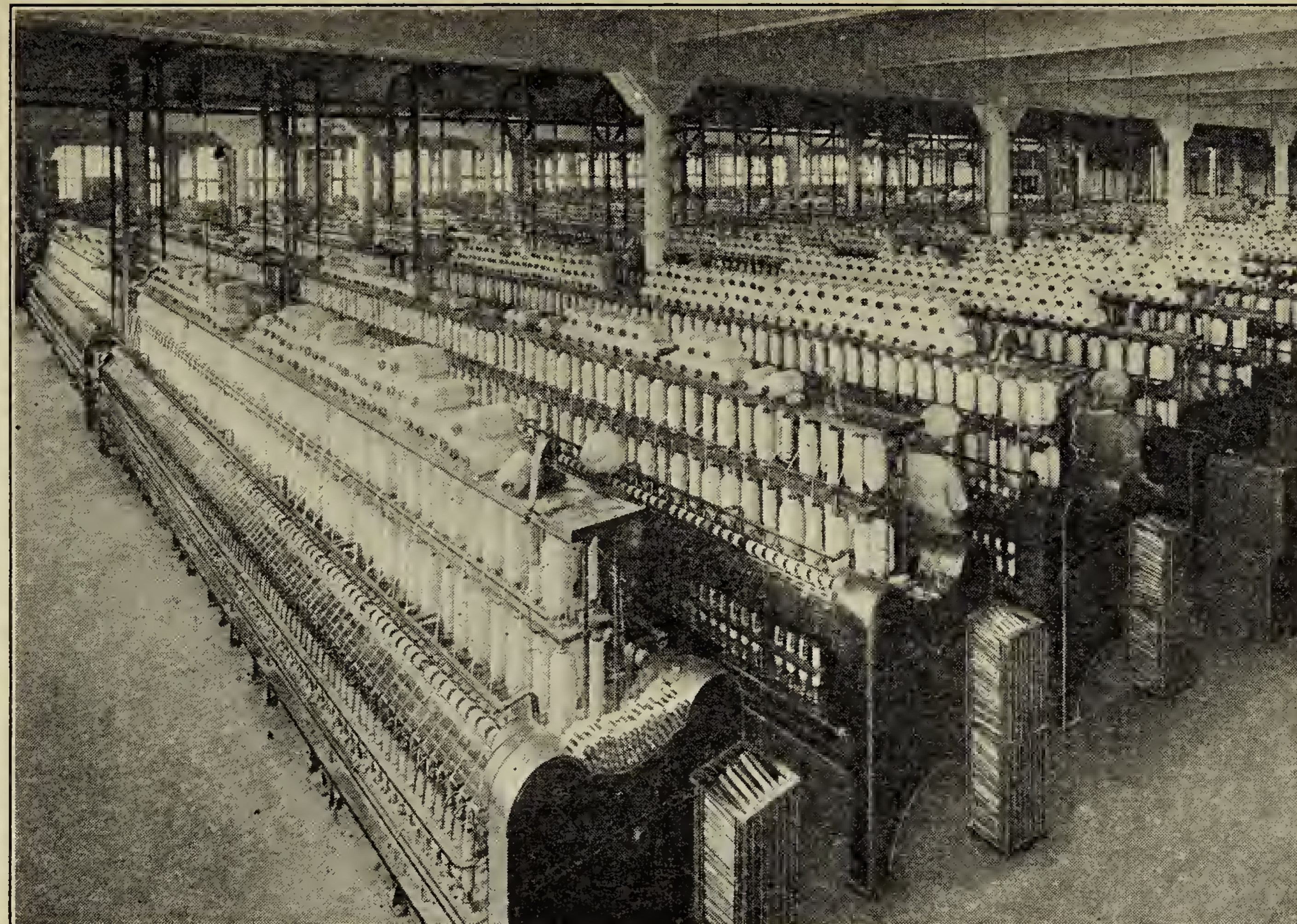
> If you wound all the yarn spun by a representative manufacturer yearly into a gigantic ball, and, after fastening the loose end, threw the ball away with sufficient force to unwind it, the ball of yarn would make about 88 complete circuits of the earth. You could unravel that wool yarn, which weighs more than 1,300,000 pounds, into a single strand more than 2,300,000 miles in length.

QUESTIONS AND ASSIGNMENTS

1. Get samples of cloth mentioned in this chapter. Ravel out and examine the yarns. In some of the novelty fabrics that have recently appeared, try to determine to what extent the character of the material has been influenced by the type of yarn employed.

2. For what else besides stockings is lisle yarn used? What is the origin of the word *lisle*?

3. Name two materials not mentioned in this chapter whose warp and filling yarns are conspicuously different in size. Name two other cloths, besides tweeds, that are made with rough yarns.



SPINNING MACHINES

Courtesy of Bemis Bros. Bag Co.

4. What information is given on a spool of cotton? linen? silk?

5. In what form do the following yarns and threads come?

basting cotton	buttonhole twist
darning cotton	embroidery silk
crochet cotton	woolen and worsted
embroidery cotton	knitting yarns

6. How can you tell the amount of thread or yarn in each form?

7. Who are some of the well-known manufacturers of cotton thread? of spool silk? of embroidery thread (cotton and silk)?

8. What is the range of sizes of sewing cotton? of sewing silk?

9. Which way does Japanese crêpe shrink most? Why?

10. Why are warp yarns finer and harder-twisted than filling yarns?

11. Write a paper on thread, silk, or yarn.

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See page 369.

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CHAPTER VII

HISTORICAL STEPS IN CLOTH MAKING

The origin of cloth making will always be shrouded in mystery, for at the dawn of history the manufacture of cloth was an old occupation. It is a far cry from the time of the cave man, when human beings possessed no clothes, no homes, and little intelligence, to the date of our earliest records, when man had become a civilized being with a developed mentality that allowed him to change the natural materials around him into forms contributing to his comfort. At some time between these two stages of man's development, however, the making of separate strands into a usable, compact fabric was evolved.

Probable uses of first textile materials. It is probable that the beginnings of the textile arts were not at all for the purpose of covering the body, but that the entwining of natural materials assisted those early people in protecting their possessions or carrying their food. The interlacing of twigs or branches for a fence around their primitive garden may have been their first weaving, or perhaps a crude basket made of leaves, twigs, or grasses, which they used for carrying nuts or berries, was their first woven fabric. Imprints on rocks of such early endeavors have been unearthed in different parts of the world and are known to have belonged to a very early stage of man's existence.

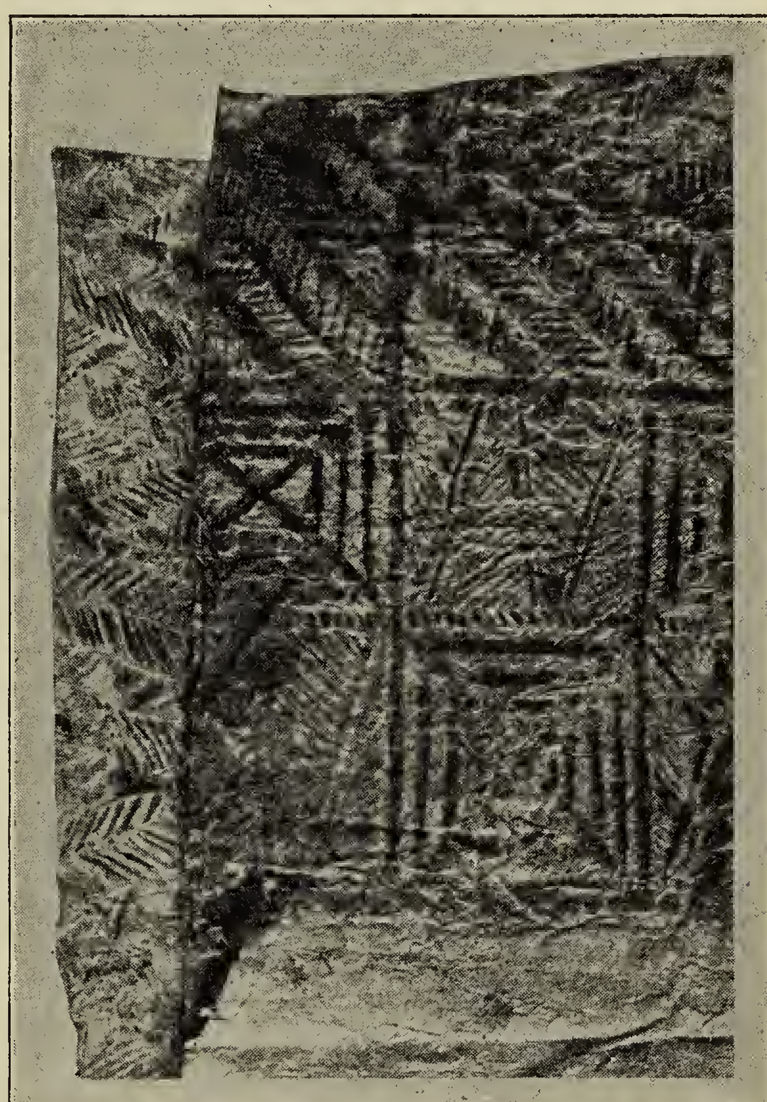
Whether the first clothing was worn for protection or for ornamentation will always be a question. Perhaps the climate in which he lived gave man the reason for wearing

clothes. Uncivilized people of today who live in the hot climates paint their bodies and decorate them with feathers, shells, beads, sashes, etc. for ornamentation, while those who live in the cold climates wear the skins of animals for warmth. Whatever gave birth to the idea of covering the body, however, clothing eventually became recognized as one of the fundamental needs of man, and today the largest part of our cloth production serves this purpose.

Theoretical beginnings of weaving. It is now quite definitely proved that the art of weaving was discovered before that of spinning. Among all the earliest specimens of weaving, the strands of materials used are as they were found in nature. There are many theories connected with the discovery of weaving. Primitive man or woman may have been inspired to imitate the bird as it wove its nest. Possibly the protection afforded by the interlacing of the branches of a particular tree may have caused man to attempt this same protection for the roof or door of his cave. It may be, as he tried to pick up his bed of rushes, that the strands had accidentally become interlaced, the separate rushes thus becoming a partly woven mat. In our museums there are relics of these crude beginnings of the textile industry, worked out in the materials of their environment by the early people of every continent. All these pieces of primitive weaving are of short lengths, governed in most cases by the length of the grass or root that formed the warp strands. These squares or oblongs of fabric were apparently first used by those early people as mats to lie upon, as covers and flaps to their cave houses, and, finally, as blankets and sashes for their bodies.

Tapa cloth and felt. In some of the hot countries where a certain species of the mulberry tree grows, a very desirable cloth was made without the aid of weaving. This was called tapa (or tappa) cloth, and beautiful specimens are found among our relics of antiquity. The principle employed in

making tapa cloth in those far-away days is the same principle that we employ in the present day in making our cheap woolen felts for household purposes, or our good rabbits'-hair felts, so much used for hats. Instead of making a solid fabric that clings together by the interlacing of strands, it is possible to obtain an equally compact fabric by using materials which, when subjected to a sufficient amount of pressure under the right conditions, cling together by the interlocking of their minute individual fibers. In the case of the ancient tapacloth the lacy inner bark of this mulberry, or cloth, tree was procured and treated, and layer after layer was then pounded together until a fabric of the right size and thickness was obtained. This cloth was very tough and enduring, and later generations of these primitive people learned the art of decorating it with natural coloring materials. In our own production of felt it has been found that



TAPA CLOTH

Courtesy University of Washington

after certain animal fibers have been properly treated, heavy continuous pressure will cause them also to cling together and produce a strong, compact fabric of any size or thickness without the aid of weaving.

Theoretical beginnings of spinning. We have no means of determining the date of the invention of spinning, but somewhere in that dim past someone discovered that a long strand could be made by twisting together short pieces of certain kinds of raw materials. As in the case of weaving, there are many fanciful conjectures about the discovery of spinning. One theory that seems plausible is that a shepherd boy, while tending his flock, picked up a piece of wool that had been torn from his sheep by the brambles and idly toyed with it in his hands, pulling and twisting it into different shapes until, lo! he had made a longer strand of wool than any root, grass, or vine that grew. Because of its length and flexibility he could wind, weave, knot, and tie this strand in more ways than any other strand he had ever handled. This is a pretty story, and whether it is true or not it gives us some idea of the joyful amazement which those early people must have experienced when they discovered that by twisting short fibers with the fingers they could make a longer strand or cord than had ever been heard of by even the oldest and wisest of their people.

Tediousness of early spinning and weaving. While wonderful old fabrics of wool, cotton, silk, and linen have been found on our continents, among their excavations, in the wrappings of their mummies, or portrayed in their rude drawings, the making of these materials was for thousands of years a slow process attended by the most tedious and exacting hand labor. There are hand-made articles of more recent date that consumed years in their production. Some of the wonderful Indian baskets and blankets take a lifetime to produce, and the real Oriental rugs require

years of painstaking effort. Even in the childhood days of our great-grandparents the younger children of the family often used to despair of ever having garments of new, "right off the piece" cloth, for often their clothes had previously been worn by several of their brothers and sisters. Not until after the age of invention, in the eighteenth

WEAVING NAVAJO RUGS IN ARIZONA

century, could cloth be produced with sufficient rapidity to allow all classes of society to be comfortably clothed.

Primitive looms. The development of the early machines for spinning and weaving is an interesting story. Some of the early looms were made by driving into the ground two rows of pegs, between which the warp yarns were stretched; or they consisted of a horizontal branch of a tree, from which the warp yarns were suspended and fastened at the bottom to a root, branch, or rocks selected for the purpose. These types of looms are still found among primitive people of

the South Sea Islands and among the Indians of North and South America. But, however crude the loom, however slow and awkward the process, and of whatever kind the raw material, the same fundamental principles were employed in this primitive weaving as are found in our most highly developed weaving plants of today. Two sets of yarns were used, arranged so that they interlaced at right angles to each other. The loom was so constructed that a shed could be made in the warp for the filling yarn. There was an instrument for carrying the filling yarn, and there was some method of battening, or beating, the filling yarns together. Indeed, the battening of the Navajo rugs and blankets is so firm that they are nearly waterproof.

The transition from such crude out-of-door looms to the well-constructed hand looms, with their cloth beams, warp beams, many harnesses, and heavy battens, that were used for hundreds of years by the people of the Eastern world and in the early Colonial days by our own people in this country, is another story in the history of textiles that we can only conjecture. The inventions that changed the weaving of cloth from a hand and home operation to a mechanical and factory operation are wonderful, as we shall see. These later achievements were possible, however, only because of the discovery of the fundamental principles by those early people.

Birth of the spindle. In spinning we have evidence of a similar progress in the making of machinery for the construction of yarn. We do not know for how many hundreds or thousands of years yarn was made by pulling out and twisting the soft fibers with the fingers. Gradually rude instruments were introduced by the spinner to assist in the process. Perhaps the first was a stick or a stone on which to wind the yarn, that a longer strand could be spun without danger of its becoming entangled or snarled when used. It may be that

as someone was twisting the strand one day it caught on the twig on which it was wound, and when it was lifted the twig began to spin, further twisting the strand. We cannot guess how many times this seeming accident occurred before someone thought, "Why not let the twig do part of my twisting for me ?" and straightway fastened the yarn around the twig, lifted it, started the twig to spinning, and watched it twist the yarn as it spun. Try this with a spool of thread or a ball of yarn and see how quickly and evenly it twists, or untwists, the end of the thread or yarn by which you are suspending it. Can you imagine the feeling of elation, perhaps of awe, of that early man or woman who discovered this principle of twisting a strand by mechanical means? With this discovery the spindle was given birth, making possible the invention of the wonderful spinning frames of our present-day textile plants. Is the wonder of these later inventions any greater, however, than the wonder of that early achievement when our prehistoric ancestors constructed the first spindle?

It is supposed that primitive man early cut a notch in his spindle, through which he drew the yarn to fasten it as he set the spindle turning. This was called the cleft. Perhaps he found that twigs varied in the excellence with which they spun, the heavier ones turning longer and more evenly than the others. In course of time, therefore, something was added to the bottom of the spindle to give it weight and balance. This added part was usually a flat disk of wood or stone and is called a whorl. With a forked branch called a distaff, which was either carried in the left hand or thrust into the belt for holding the material to be spun, and with his spindle having a cleft in the side and a whorl at the bottom, our spinner (or spinster, as she was called if a woman) was fully equipped to produce the yarn that was to be woven into cloth.

The spinning wheel. For hundreds of years all yarn was produced by these simple implements, but inventions must

have taken place, and the next machine for spinning of which we know anything is the spinning wheel. It is believed that the spinning wheel was invented in India, as the old Gherka wheels found in that country are the most ancient ones known. Between the fifteenth and the eighteenth century, spinning wheels were used by the people throughout Europe

HAND CARDING AND SPINNING

and by the early colonists here in America. They are still used in isolated localities on both continents. The spinning wheels of different countries differed in size and style of frame, but the principle of twisting the yarn was the same in all the wheels. This was done by having one end of the yarn held in the fingers while the spindle attached to the other end was turned at the will of the spinner by means of the wheel which he directly controlled. Two types of spinning wheels predominated, and numerous examples of each are still found

among the treasured possessions of many of our families. One of these types was used for spinning wool and was called the great, Jersey, or wool wheel. The other was used for spinning flax and was called the flax wheel or Saxony wheel. These two wheels differed in some essentials, and these differences have been passed on to their direct descendants, which are the highly perfected spinning machines of today. The process of spinning with the wool wheel was similar in many respects to spinning by hand with the spindle. With this wheel the spinner stood, attached one end of a roll of carded wool to the spindle, and held the other end in his left hand. As he started the big wheel turning with his right hand he stepped back several steps, *drawing out* the wool at the same time that it was being twisted by the swiftly revolving spindle. When the yarn had been drawn out fine enough and was sufficiently twisted, he stopped the spindle by stopping the big wheel, jerked the yarn to the rod of the spindle, turned the wheel gently, and wound it on the spindle as was done in primitive hand spinning. The end of the yarn was then brought to the point of the spindle, the wheel was started, and the spinner stepped back and drew out the yarn until it was in the right condition, when the wheel was again stopped and the yarn wound on the spindle. The regular stopping to wind the yarn causes this wheel to be spoken of as having intermittent motion, a motion which we still find in our factories. It is fascinating to watch spinning with the wool wheel. The soft whirring of the spindle, alternating rhythmically with the steps of the spinner as he paces back and forth from his wheel, has been a source of inspiration to poets and musicians, both of whom have perpetuated the music of the spinning wheel in their own way.

The flax wheel was a more complicated piece of machinery. The spinner sat and operated the wheel with a pedal as we run a sewing machine. The most essential difference, how-

ever, was that by means of an attachment called a flyer the yarn could be twisted by the spindle and wound on it at the same time. There was a distaff on this wheel, from which the spinner dexterously drew out the material with his fingers while with his feet he kept the spindle turning. With the flax wheel the motion was continuous and the three operations in spinning — drawing, twisting, and winding — were done at one time. In our early Colonial days, when spinning and weaving were household industries, the ability to spin rapidly a smooth, even yarn was a high recommendation for any young woman. It is said that at one time there was a spinning contest among the young ladies in Boston, and for the test they took their wheels out and spun under the trees on the common. What a pretty sight it must have been!

For a long period of time (we shall never know the exact number of years) all the cloth produced was woven on the hand loom, and all the yarn required for that cloth was spun on spinning wheels. Both spinning and weaving were largely done by men, the number engaged in spinning being such as to keep the supply of yarn produced equal to the amount demanded by the weavers; in other words, these two hand industries kept pace with each other. Spinning and weaving were slow processes in those days. Only one yarn could be spun at once on a wheel, and this required all of one man's time. Compare this with the thousand or more yarns being spun simultaneously on a modern mule, requiring the time of only one skilled man and one or more assistants. The weaving of a single piece of cloth, if of medium width, necessitated the concentrated attention of one man, and if of extra width, of two men. Today there may be as many as 2000 pieces of cloth being woven at a time in one weaving shed, the shuttle moving at the rate of 200 or more picks per minute and the attention of only one person being required for every 20 or more looms.

Important inventions and discoveries affecting the textile industry. 1. *Textile machinery. a. Spinning by rollers.* At the beginning of the eighteenth century many world changes had taken place. A new continent had been discovered, new routes of travel were developing, population had increased, and new needs arose. The old slow ways of producing cloth were becoming inadequate. Inventions usually follow a strong feeling of need in the minds of the people. This condition existed during the World War and caused the wonderful inventions of that time to be produced. Likewise, the dire need of a greater cloth production caused the wonderful inventions of textile machinery that took place between 1730 and 1830. There were doubtless many unsuccessful attempts to make machines that would do more of the work of spinning and weaving than any known at the time, but the earliest introduction of an entirely new principle in either operation was in 1738 or 1739, when two spinners, Lewis Paul and John Wyatt of Birmingham, England, worked out a crude machine in which yarn was drawn out and twisted by rollers instead of by means of the spinning wheel and the fingers. This machine was never perfected, so it was soon forgotten, and the spinners kept on producing yarn in their old way.

b. The fly shuttle. Many active minds were studying the problem of increasing the production of cloth, however, and about that same time John Kay, a weaver of Bury, England, invented the fly shuttle, which materially increased the rate of weaving. Up to this time the shuttle containing the filling yarn had been thrown by the right hand through the shed across to the left edge of the warp, where it was picked up by the left hand and thrown back through the next shed to the right edge of the warp. For wide cloths an extra man had to stand at the left of the loom to throw the shuttle back. Kay invented a spring which released a rod that automatically

drove the shuttle from edge to edge of the warp yarns. The use of this simple device increased the production of woven cloth fourfold.

c. The drop box. About twenty years later, in 1760, John Kay's son, Robert Kay, invented the drop box, which allowed a shuttle containing a new filling yarn to replace automatically one in which the yarn was exhausted or was no longer to be used. These two inventions so speeded up the weaving process that there was by this time an incessant call for "more yarn," "more yarn," stimulating an increased rate of spinning; and, as always, there were those who heard the call.

d. The spinning jenny. Between 1760 and 1765 there lived in Blackburn, Lancashire, a poor and hard-working spinner named James Hargreaves, still spinning one yarn at a time by means of his spinning wheel and fingers. In all spinning wheels the spindle is set in a horizontal position, but it is said that one day he accidentally tipped over his wheel while it was in motion, and it still continued to turn the spindle, even though it was in an entirely different position. This suggested to Hargreaves the possibility of spinning more than one yarn at a time, and he worked out a machine with upright spindles turned by means of a belt, as in his spinning wheel, but with the power to spin from 8 to 11 yarns at once. He called this machine a spinning jenny; it is supposed in honor of his wife, who bore that name. (Another historian claims that the word *jenny* is a corruption of the word *jinny*, from *engine.*)

Hargreaves was happy over his invention and felt that he had achieved a great success, which was indeed true. He could now produce many times the amount of yarn formerly spun, and could do it more easily. But his happiness was to be short-lived. He was a poor man with little power or influence. He had neither the money nor the ability to

promote his invention or defend it from the attacks of his enemies. The guilds of those days were very jealous of their industries and guarded their work closely. Fearing that machines were being invented that would displace the human workers, the spinners fell upon Hargreaves and his invention, wrecking his machine and beating him cruelly. Hargreaves died a poor, discouraged man, but the principles that he discovered are still used in some of the largest mills in the world, and his name will always live among the great inventors.

e. The water frame. The spinning jenny used the intermittent motion of the great spinning wheel and spun a soft, even yarn, very desirable for the filling. It was neither strong enough nor hard-twisted enough for the warp, so immediately a cry went up for more warp yarn. A wide-awake, ambitious young barber of Preston, England, heard this call as he went about from place to place, and he began working on a machine that would spin several yarns at once but would operate by the continuous motion, making a more tightly twisted yarn. History speaks of this young barber, Richard Arkwright by name, as being very willing to use and build upon the efforts of other people, and it is thought by many that he absorbed the principles employed by Paul and Wyatt in their invention of 1738. At any rate, in 1769, a few years after Hargreaves's invention, Arkwright produced a machine that would spin by means of rollers and was operated by water power. Its motion was continuous and it spun a strong, tightly twisted yarn especially good for warp. This machine filled a great need in the spinning world, and its inventor, Richard Arkwright, was a sufficiently good business man to make a financial success of his invention. Arkwright was knighted by the king and died a wealthy man.

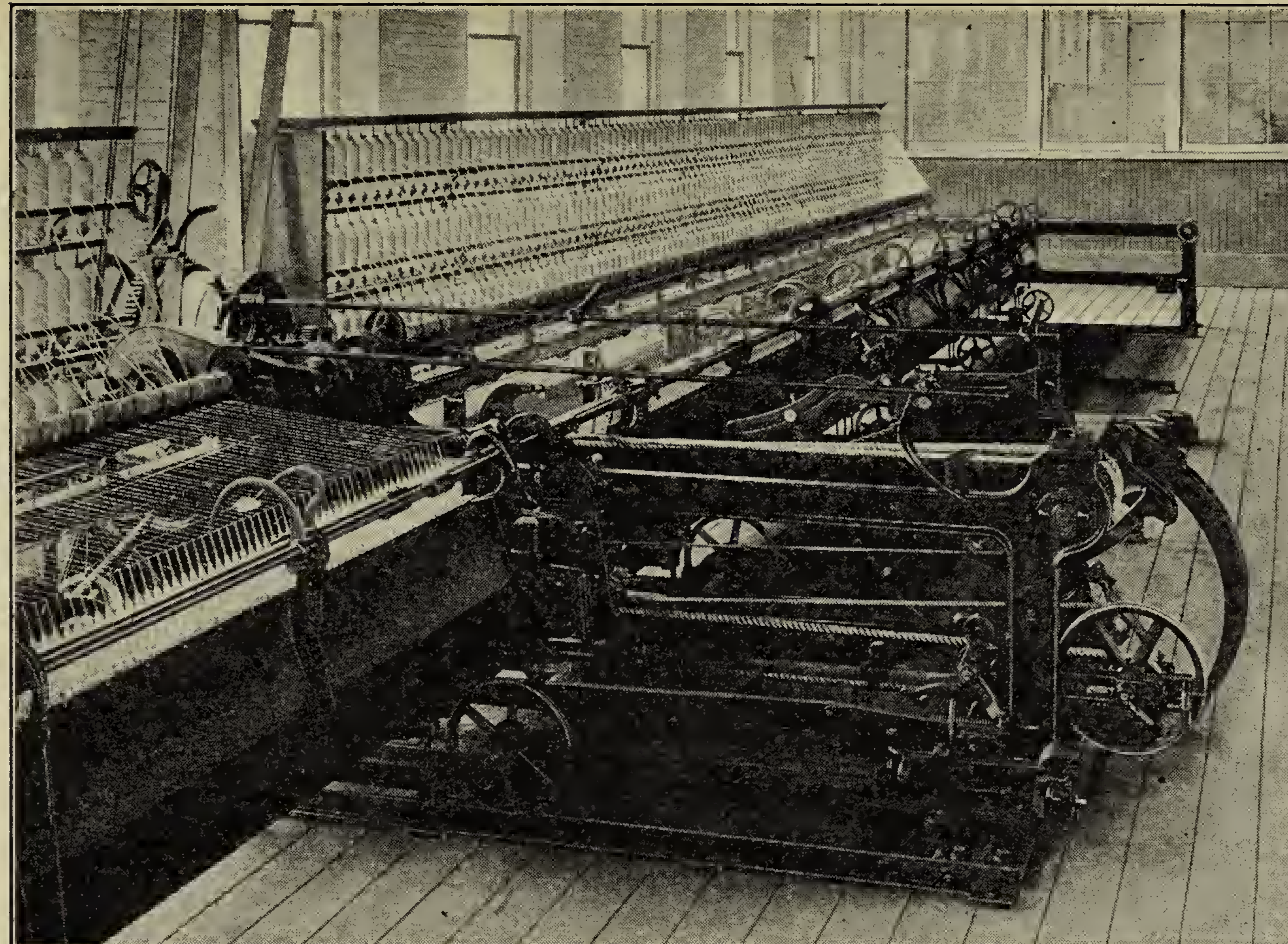
f. The mule. It is always true that the appearance of an invention stimulates the desire to improve it or produce a

better one, and such was the case with the early textile machinery. In 1779 Samuel Crompton, a capable textile worker of Bolton, England, produced a spinning machine which he named the mule because it seemed to be a cross between the inventions of Hargreaves and Arkwright. This mule employed the intermittent motion of the jenny but also contained some of the principles used in the water frame. It was the progenitor of the mule spinning frame, which we find in the factories of today. The spinning of these modern mules is fascinating to watch. As in the wool wheel from which they were developed, the yarn is drawn out and twisted in one operation, but in the mule many strands are carried by machine fingers instead of the one strand by human fingers. Then comes a pause in the process, while the carriage of the machine holding the yarn moves toward the mule frame, winding the many strands of twisted yarn on the spindles as it does so; in olden days the spinner walked toward his wheel, winding his one yarn on the spindle as he walked.

The mule spins a soft, elastic yarn very desirable in woolen goods and much used in some classes of cotton goods, but its intermittent motion causes its production to be relatively slow.

Arkwright's water frame, with its continuous motion, has received many modifications and improvements, and its successor is now found in the various types of ring spinning frames of our factories, which perform the three operations of drawing, twisting, and winding at one time, the spindles turning at the rate of 10,000 or more times a minute.

g. The power loom. Up to 1770 more progress had been made with the spinning than with the weaving machinery, but after James Watt showed to the world the practicability of the steam engine, in 1769, inventors struggled to make use of this wonderful power in the weaving of cloth. It remained for a man far outside the textile industries to give



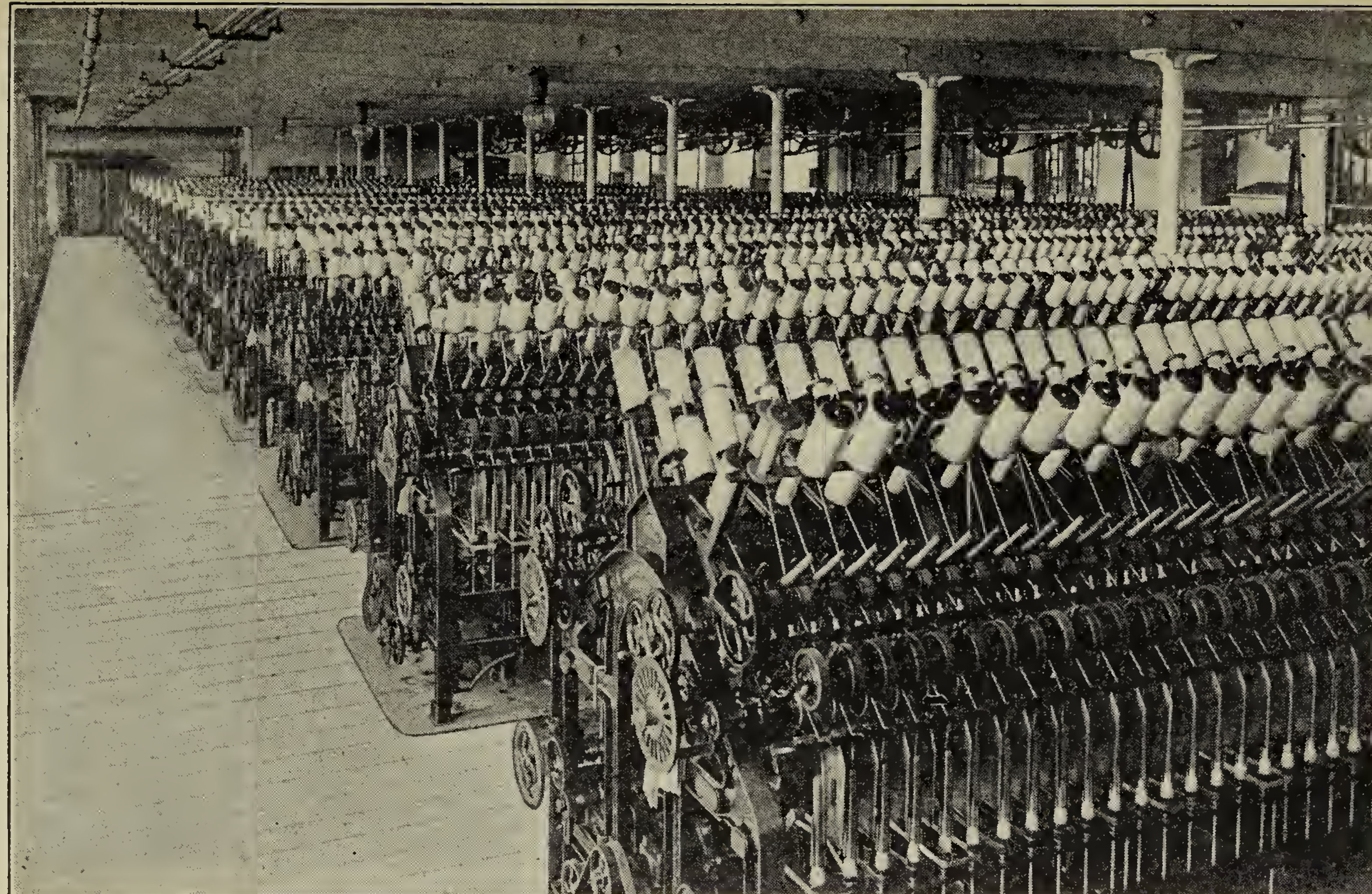
A MULE

Note the many threads being spun. (Courtesy of Mason Machine Works)

the world an invention that the textile workers had long been seeking. In 1785 Edmund Cartwright of Leicestershire, a minister of the Church of England, built the first power loom. Dr. Cartwright had no practical knowledge of weaving or of mechanics, and his first loom was a clumsy, almost grotesque affair. He had solved the problem of accomplishing the three operations of weaving by mechanical means, however, and two years later, in 1787, he had so perfected his machine that it was similar to the looms of today.

h. The Jacquard loom. It would be well-nigh impossible to enumerate the improvements and additions that have been made to that first power loom invented by Dr. Cartwright, but two other names connected with loom inventions will probably always live in the textile world. One is the name of Joseph Marie Jacquard, a Frenchman who taught experimental fancy weaving in the Palace of Fine Arts at Lyon, France. He is reputed to be the man who invented the first machine for making fishing nets, and of whom Napoleon asked, upon hearing of his achievement, "Are you the man who can do what God Almighty cannot,—tie a knot in a taut string?" The name of Jacquard, however, is not usually associated with fishing nets, but with the wonderful loom which has been described in Chapter III, and which will probably always bear his name. This loom was invented in 1801 and was the first machine to do practical design weaving. Like many of the other inventors of textile machinery, Jacquard incurred the hatred of the weavers of those days and met with much persecution. At one time, it is said, he was compelled to flee for his life. Gradually, however, his invention was adopted, until today the Jacquard loom has become indispensable in the production of textile fabrics.

i. The Northrop loom. The Northrop loom, which is so universally used in weaving plain cotton fabrics of today,



RING SPINNING FRAMES

Courtesy of Amoskeag Manufacturing Company

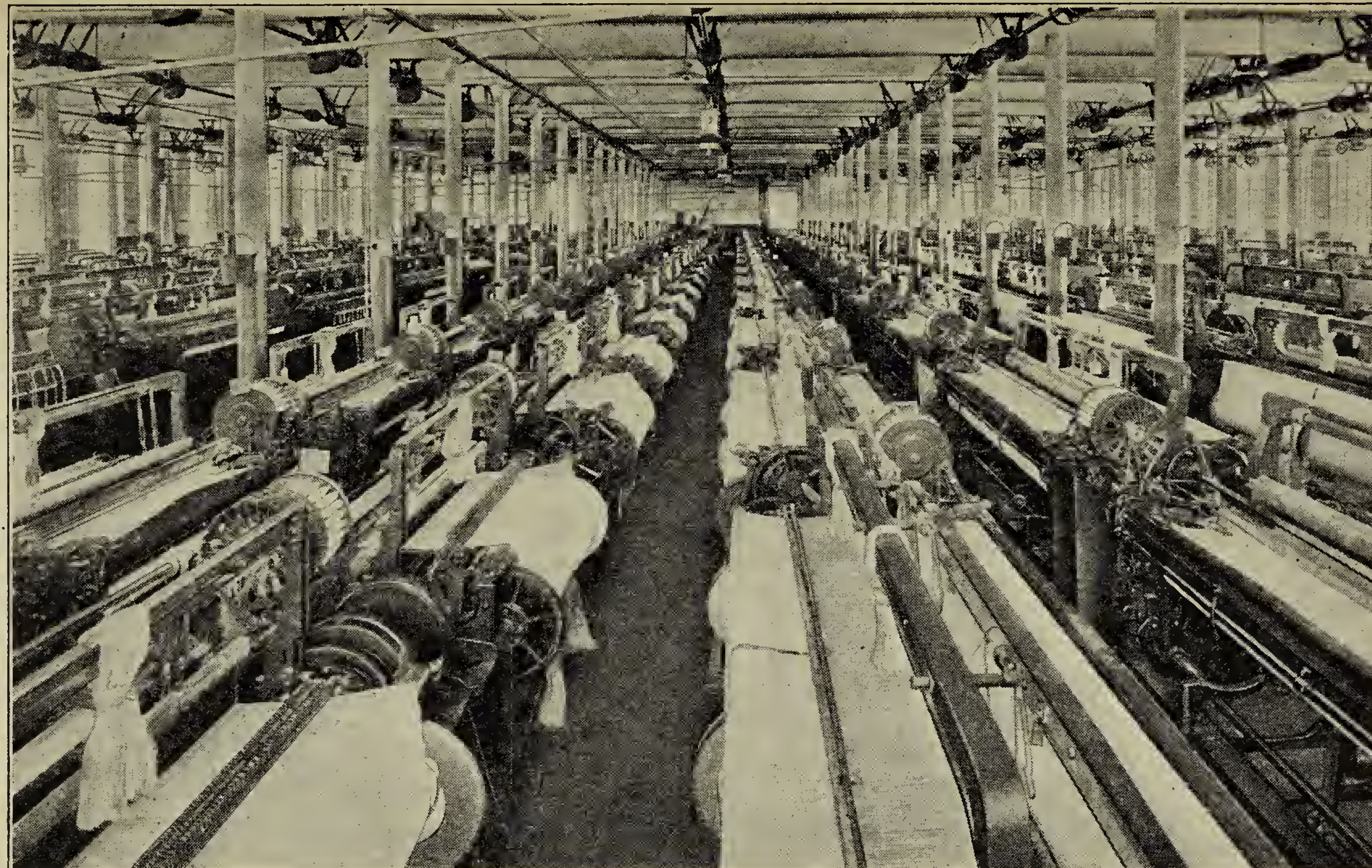
is the result of the inventive genius of James H. Northrop, an Englishman, who began working for an American firm in 1889. This loom, with devices for automatically supplying filling yarn, threading the shuttle, and stopping the motion in case of a broken yarn or other accident, has made human intelligence almost unnecessary in plain weaving.

j. Knitting and lace machines. Knitting, as well as weaving, was for a long period of years a hand process, and during the years of the World War almost every woman learned to make hand-knitted articles for our soldiers. In times of peace, however, most of our knitted garments are made by machinery, thanks to the inventive genius of William Lee of Nottinghamshire, England. From his crude machine of 1589 have been developed the intricate knitting machines that construct our elaborate neckties and lace stockings of the present day.

The lace machine constructed in 1809 by John Heathcoat of Leicestershire, and improved a few years later by John Leavers of Nottingham, England, has been described in the foregoing chapter. At the present time both knitting and lace machines have become so highly perfected that their productions are little short of marvels.

The men whose names have been given above affected the history of cloth making by the invention of new and wonderful textile machines. If we were to mention all those who have made useful contributions to textile machinery, we should have a long list of names. All the unmentioned inventors merit great credit, but their achievements were usually additions and attachments to the discoveries of those first great men.

2. *Kinds and amount of raw material. a. Great increase of cotton.* The textile world has also been affected at different times by the introduction of a new kind of raw material or by an increased supply of some kind already



A MODERN WEAVING ROOM

Courtesy of Wamsutta Mills, New Bedford, Massachusetts

known,—the result of original thinking upon a slightly different problem. As late as 1793 a comparatively small amount of cotton cloth was manufactured, because of the difficulty of obtaining the cotton fibers. Cotton grows very easily in many parts of the world, but the lint clings tenaciously to the seeds, from which it must be separated before being used. The natives of India had manufactured cotton fabrics for thousands of years, pulling the fiber from the seeds by hand. It remained for Eli Whitney, a New England schoolmaster who had never seen a boll of cotton until a few months before his invention, to construct a machine that would quickly and easily strip the fiber from the seeds. He called his invention a gin, which is the shortened form of the word *engine*. It has since been discovered that a crude machine for the purpose had been used in India at a much earlier period, but Whitney knew nothing of this. His invention was inspired by what he saw,— the flourishing fields of cotton in the South and the monotonous drudgery required to separate the fibers from the cotton bolls. A worker could clean only about a pound of cotton by hand in a day, while with this machine 500 pounds could be cleaned. At the present time some of our large ginneries clean 5000 or more pounds of cotton a day.

b. Use of silk waste. Another useful addition to textile raw materials came with the invention of a method by which silk waste could be converted into a usable yarn. For many years only the long strands reeled from the cocoons were used for silk yarns, the short and broken filaments being thrown away as refuse. As about one third of all the silk fiber in the world consists of weak filaments tangled by the worm in spinning, and broken fibers made by man in manufacturing, large quantities of strong silk were thrown away every year. In the latter part of the nineteenth century, when textile machinery was being much improved, a way to card and spin these broken fibers of silk was found, and

now "spun silk" furnishes much of our yarn for silk knitted goods and many woven materials.

c. Introduction of artificial silk, or rayon. At an even later date an entirely new textile fiber appeared, whose use increases widely every year. It is a synthetic silk, called rayon, and strongly resembles real, or worm, silk. Rayon is a chemical production, at first called artificial or fiber silk; it was discovered by a Frenchman, Count Hilaire de Chardonnet, in 1884, but it was not made commercially practical until about 1900. It is made by extracting the cellulose from certain plants (spruce trees and cotton plants being particularly good for the purpose), then treating it with chemicals in such a way as to reduce it to a semi-liquid substance. When this gelatinous material is forced through tiny apertures into the air, it immediately hardens into a straight, strong, glistening fiber. There are different methods of producing this fiber, and rayon frequently bears the name of the method used in its production. Consequently there are viscose rayons, nitrocellulose rayons, cuprammonium rayons, and cellulose-acetate rayons. These rayons are, however, quite similar in character and appearance.

3. *Varieties of cloth. a. Employment of aniline dyes.* New discoveries connected with the finishing of cloth have done much to increase the varieties produced within the last fifty years, and therefore to extend its usefulness. The discovery of aniline dyes in 1856, by Sir William Henry Perkin, an English chemist, revolutionized the coloring of cloth. Before that discovery, when vegetable and animal dyes were used, the number of colors was limited and their application to some kinds of material (particularly cotton) was difficult. Turkey red and indigo blue were old stand-bys in cotton cloths, but many of the other colors were less reliable. The introduction of aniline, or coal-tar, dyes solved the question of cotton dyeing and printing, and today we can find

every hue represented among our cotton goods. Look at our ginghams, calicoes, percales, madrases, and cretonnes and see what Sir William Henry Perkin did for the textile world.

b. Process of mercerization. Another discovery in the finishing process has given us substantially a new fiber, for a chemical treatment has so changed the character of the cotton fiber that both its appearance and its behavior are very different from the natural cotton. This change is brought about by the process of mercerization, which was discovered accidentally, we are told, by John Mercer, an Englishman. When Mercer died, more than twenty years later, his discovery had not been made practical, so he never knew of his great contribution to the textile world. But mercerization (the process that bears his name) has since given us an entirely new kind of cotton material, which strongly resembles silk or linen and can be bought for a much lower price. These discoveries of Perkin and Mercer have added much to our enjoyment of cloth by giving us beautiful fabrics at a low cost.

The textile industry in the United States. 1. *Introduction of the factory system.* The history of the evolution of the factory system, which was brought about entirely by the textile industries, would make a complete book in itself, and we shall not even attempt to touch upon this subject. The man who was responsible for the introduction of the factory system in this country was Samuel Slater, who came from England in 1789, bringing "in his head" the models of textile machines which were used in England at that time, but which were forbidden exportation. Machines for spinning and weaving were made here in America under his direction, thus transferring the making of cloth in this country from the spinning wheels and hand looms of the home to the spinning frames and power looms of the factories. Samuel Slater is called the "father of the factory system" in America.

2. *Present importance of the industry.* The first complete textile mill in America was established at Rowley, Massachusetts, in 1643. Note the growth of textile manufacturing in the United States in less than three centuries since that time! A recent enthusiastic writer who compares New England before and after the introduction of the textile industry[1] says:

> Today the shipping has disappeared and the textile industry has dotted the face of New England with the great mill centers, which are beehives of production, whirring with millions of spindles, clattering with thousands of looms, rumbling with thousands upon thousands of pulleys and shaftings, and turning out millions of dollars' worth of fabrics of every description.

There are now in this country thousands of mills in which the raw material is changed into the woven cloth, and more than one million of our people are engaged in the industry.

QUESTIONS AND ASSIGNMENTS

1. Give advantages and disadvantages of the factory system.

2. What were the guilds? Describe the Industrial Revolution.

3. Why were most of the early inventions in textile machinery by Englishmen? What did France contribute?

4. What are some of the large European textile centers?

5. Name some important cloth manufacturers in the United States. Where are their factories?

6. Read one of the following books:

   "John Halifax, Gentleman," by Miss Mulock
   "Mary Barton," by Mrs. E. C. Gaskell
   "Alton Locke," by Charles Kingsley
   "Working with the Working Woman," by Cornelia Stratton Parker

7. Name five noted inventors of the present day. Give name and date of their inventions.

8. Write a paper on the life of one of these five men.

9. What periodicals give information about inventions?

[1] Perry Walton, Story of Textiles, p. 249.

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CHAPTER VIII

COLORING AND FINISHING OF CLOTH: BLEACHING AND DYEING

Effect of the application of color to fabrics. One of the few fundamental causes for the many kinds of cloth now to be found is the great variety and innumerable combinations of colors that are applied to textile materials. A comparison of some of our well-known fabrics will quickly disclose this fact. What but color causes the difference in appearance between the grayish-yellow unbleached muslin that we make into house aprons and the pure white muslin of the same weight that we use for bed linen? Is not the apparent difference between two kinds of cotton materials with satin weave really due to the type of coloring, so that we buy from one piece for children's rompers and play suits, and from another of precisely the same weave and weight, but bearing a different name, for covering mattresses, pillows, and cushions? Does not color govern the uses of some of our pile-weave cottons, classifying one group as bath towels and another group of the same weave as draperies? The white twilled material in Mary's middy, which is called drill, may be identically the same weave and weight of cloth as that in Roy's camping suit, which is called khaki; and the only difference that we can detect between the brown linen crash in our kitchen towel, the snowy white uniform of butcher's linen that the nurse is wearing, and the stylish suit displayed in the store window may be the different colors represented in these fabrics.

We see, therefore, that frequently the differences between cloths that appear so unlike and are put to such different uses have been caused neither by weave nor by kind of raw material, but by color. In some cases the natural color has been extracted from the material, rendering it a pure white, and in other cases color has been applied to a part or the whole of the cloth, causing it to appear like an entirely different fabric and consequently to be used for quite a different purpose. This change from the natural color of the fiber to the pure white of some materials, the plain color of others, and the many-hued patterns of still others may take place in the raw fiber or in any stage of yarn making. It occurs most frequently, however, in the constructed material, and when applied to the great masses of cloth in a mill the operations of bleaching and dyeing are most interesting.

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INSPECTING CLOTH

Treatment of cloth before bleaching. 1. *Inspecting.* A great many things have to be done to a piece of cloth between the time it is taken from the loom where it has been woven and the time it is ready to be sold in the store or made into a garment. The first operation after weaving is always the examination, or inspection, of the cloth to discover and correct any imperfections in its manufacture. This operation

bears various names (as *inspecting*, *burling*, or *perching*), according to the nature of the goods manufactured, but the purpose is the same in all cases. It is to remove all knots, loops, and ends from the surface of the cloth and to mend all weak and torn places. This work always takes place in a good light, the inspectors sitting or standing before a frame over which they draw the cloth slowly enough to examine every inch of it as it moves along. Sometimes the imperfections are so bad that they cannot be obliterated by mending, and the material is not of first quality. Goods sold in the stores as seconds are of this kind.

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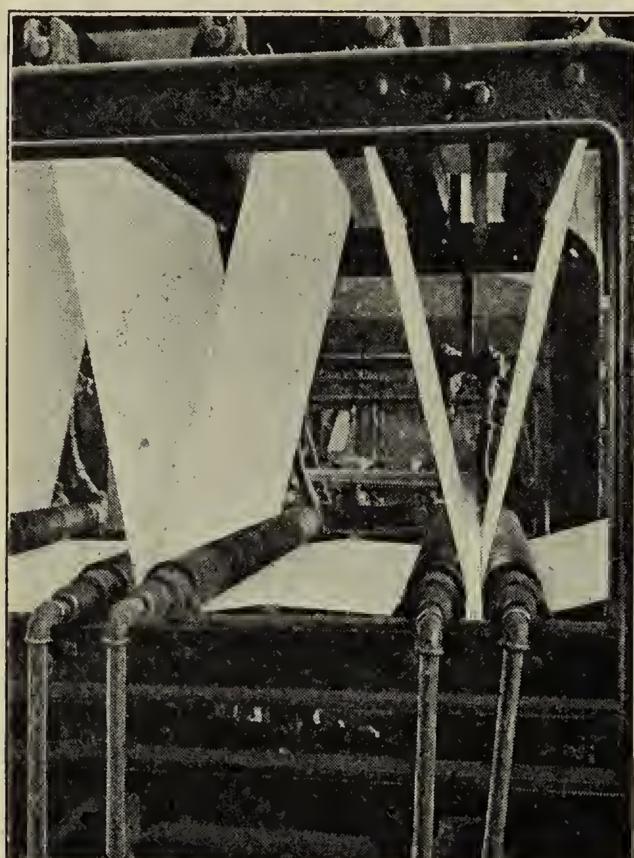
SEWING THE LENGTHS OF CLOTH TOGETHER

2. *Washing*. When a piece woven from yarns in their natural color is taken from the loom, it is spoken of as "in the gray" and is usually more or less soiled from the manufacturing operations. After inspection and mending, the next operation with most fabrics except silk is washing, or scouring. For this and the other finishing processes the lengths of cloth that are to receive the same treatment are sewed together, end to end, until there may be a strip many miles in length. The handling of the material in these long strips greatly facilitates its progress through the finishing operations, as the cloth can thus be passed continuously

from vat to vat, from machine to machine, or from room to room in the factory without loss of time or interruption of process.

The manufacturers of cloth do not always finish their own materials. The equipment and conditions that are necessary for the bleaching, dyeing, and mercerizing of these long strips of cloth are sufficiently expensive and important to make the finishing of cloth a separate branch of the textile industry. There are large plants scattered throughout our country that bear the name of the process they perform, as bleacheries, dye works, and print works. In large manufacturing plants the finishing processes may take place in a separate building on the home ground. In many cases, however, the cloth maker ships his goods in the gray to a finishing plant (which may be many miles away), where the cloth is put into the condition in which it finally appears.



SINGEING THE SURFACE OF THE CLOTH

3. *Singeing, or gassing.* An interesting treatment which is highly essential to some fabrics usually takes place before any of the other finishing operations. It is a delicate mechanical operation which consists in removing all lint or fuzz from the surface of the cloth. This is done sometimes by shearing with a machine working on the principle of the

lawn mower, but most often by singeing, or gassing. Small jets of flame are used, and the cloth is passed by rollers through these flames at such a rate of speed as will burn off all the tiny projecting fiber ends and yet not injure the cloth. The same principle is used in singeing cloth as in singeing a chicken, and results in the same clean, smooth surface. Look across the face of a piece of unbleached muslin and then of a piece of high-grade bleached sheeting and you will see the effect of the singeing process.

Bleaching. 1. *Cottons and linens.* At home, if a cotton or linen article has become yellow from being laid away, or gray from improper laundering, the intelligent housekeeper tries to bleach it to a snowy whiteness again. Usually she soaps and boils it, then puts it out in the bright sunshine. If possible, she spreads it on the grass, or if clean snow is on the ground she spreads it on the snow. She may let the article lie out in the sunshine for a week or two, perhaps taking it in to soap and boil in the meantime, wetting it at least once a day and lifting and turning it often, so that it will not mildew. If the article is very yellow, like old lace or fine, old handwork that has been laid away for a long time, she may dip it in a chloride-of-lime solution or Javelle water. If either of these two chemicals is used, it must be washed out very thoroughly immediately afterward, or it will "rot the goods," as we say.

The same principles that the painstaking housekeeper uses in the whitening of her household and family linens are employed in all manufacturing plants, whether large or small, where cottons or linens are bleached. Instead of the ordinary laundry tubs and boiler that will hold an average family washing these plants have huge kiers and tanks that will hold miles or tons of cloth and are large enough for men to get down into and lift, stir, or place the cloth. To give some idea of the vastness of the operations in commercial

bleaching I quote from a letter from Mr. Sidney Coolidge, Treasurer of the Lowell Bleachery, Lowell, Massachusetts:

> Our iron kiers hold 8000 pounds of cloth, and this weight in some kinds of material means a strip 40 miles long. Some days we put into process six times this amount, which, if conditions were just right, would mean six lengths of cloth, which, if put end to end, would stretch more than the distance from New York to Washington, D.C.[1]

The treatment of cloth in the bleacheries is similar to that given in the home. The bleaching solutions, however, must be chemically exact, the temperature of the water kept to the required degree of heat, the number and order of operations definitely fixed, and the length of time the cloth is exposed to any one of the treatments exactly determined. In other words, in the manufacture of cloth the process of bleaching is a continuous, scientific operation, whereas in the home it may be a more or less intermittent and inexact operation.

The main steps in the bleaching of cottons and linens in all bleacheries are the same. The goods must first be rendered entirely free from all dirt, grease, or stains produced in its manufacture, and from all natural oil, gum, or wax. To do this the cloth is put into the great kiers and boiled for hours in a weak caustic-soda solution. At the end of this time it is taken out, washed, and soaked in a dilute acid which neutralizes the action of the soda and removes rust spots. The cloth is then fed back into the kiers and boiled again for several hours, after which it is thoroughly washed and immersed in the bleaching solution. This bleaching solution contains chlorine in some form, as does the chloride of lime or Javelle water that we use at home for the same purpose. This is the chemical that oxidizes the coloring matter and makes the cloth a pure white. By its use only a few hours are re-

[1] A fast express takes at least five hours to cover this distance.

quired to produce the same degree of whiteness in fabrics as can be accomplished by the sun in days and weeks.

After immersion in the bleaching solution the cloth is delivered into huge tanks, where it is allowed to steep for a number of hours, after which it is thoroughly washed and the bleaching process is finished.

These are the general principles of commercial bleaching, but the number of times the cloth has to be handled to obtain the desired result cannot be fully appreciated by one unfamiliar with the work. To quote again from Mr. Coolidge: "In these iron kiers the cloth is boiled twice from ten to twelve hours, and during the entire process of bleaching it is washed and rinsed one hundred and forty times."

Because chlorine is a powerful chemical great care must be taken in its use, lest its action make the cloth tender as well as white. The writer has had several garments of snowy white material which was very attractive to look at but which fell into shreds after short use. The cloth had been "tendered," or rotted, in the bleaching process. The bleaching solution must be of exactly the right strength for the kind and amount of material immersed and the degree of bleach to be given. The length of time goods is steeped must be accurately determined by a trained person who knows when the danger line is reached. All cloth is somewhat weakened by the bleaching process, but if the bleaching has been intelligently done there is no serious loss of strength. When hard wear rather than attractive appearance is the object, unbleached materials will give much better service than bleached materials. Our Colonial grandmothers, whose families were often large and whose purses were correspondingly small, bought unbleached bed and table linen and bleached it in the sun.

Among linen damasks we find various degrees of whiteness, from the unbleached to the quarter-bleached, half-

bleached, three-quarters-bleached, and full-bleached cloths. Many damasks are made with one of the sets of yarns of natural color or only partly bleached. Formerly the finest Irish linens were grass bleached, and the spreading and care of these long strips of cloth on the grass was one of the important operations in the Irish linen industry. Entire grass

GRASS BLEACHING IN IRELAND

bleaching is a long process, and probably no linens at the present time are bleached in this way. Grass bleaching, or crofting, as it is called, is still employed with the best Irish linens, however, though the term *grass bleaching* now means that the bleaching has been finished in that way. Much of the whitening has been accomplished first by the chemical process.

Some kinds of cloth are left in their natural color. Silk pongee, unbleached muslin, plain white flannel, and brown linen crash are examples of these cloths. In making these

goods the bleaching process is omitted; but in making all pure white goods, and many goods that are to be dyed or printed, the clearness of color is obtained by first subjecting them to the bleaching process.

2. *Silks and wool materials.* The method of bleaching described is not used for silks and wool materials. These goods are made from animal fibers which would be injured by a chlorine bleaching solution. Sulphur in some form is used in bleaching these fabrics. Either sulphurous acid is used for the bleaching solution or the goods are subjected to the fumes of burning sulphur. Peroxide of hydrogen is also much used as a bleach for silks and wools. Both of these materials tend to revert to their original color, especially if frequently laundered. Peroxide of hydrogen in the rinsing water (one teaspoonful to a quart of water) each time it is laundered assists in keeping white wash-silk garments from becoming yellow. Letting garments lie in this solution will not injure the fabric. Fortunately animal fibers take dye readily, and most silks and wools used for wearing apparel are colored. Tinted silk underwear and pajamas and colored silk stockings and gloves are more practical and usually more popular than white ones. White flannels for men and white wool suits for women are very attractive when new, but require careful treatment if they are to be kept a pure white.

Dyeing. Bleaching deprives cloth of color (unless we consider that white is all the colors combined, which is strictly accurate), and dyeing gives cloth color. Like bleaching, dyeing may be done in the raw material or in any stage of the yarn making, but the dyeing of the cloth (piece dyeing, as it is called) is the most interesting process. Cloths that are to be dyed light colors or are to have colored designs in which clear white is necessary must be bleached before being dyed. Dyeing, like bleaching, is more of a chemical than a mechanical operation, and the beauty and durability of both the

color and the fabric after the cloth has been dyed are dependent upon those who mix the color solutions and guide the dyeing operations.

1. *Natural dyes.* There are two great classes of coloring materials used in dyeing and printing cloth: natural dyes and artificial dyes. The natural dyestuffs have been used from time immemorial. They were the materials used for stamping tapa cloth before the process of weaving was known. They furnished the many colors in Joseph's coat of Bible times. They are the dyes used for the beautiful rugs and shawls that have made Persia and India so well known. The soft, mellow colors found in old Indian blankets, baskets, and pottery were made from Nature's paintbox that lay all around the Indian's wigwam.

Of these natural dyes a small group, like the cochineal red and the squid sepia, are produced from animals, while another group, like Prussian blue, chrome yellow, and iron buff, are found in minerals. But by far the greatest source of natural coloring materials is in the plant world. Color can be extracted from a limitless number of barks, roots, leaves, flowers, nuts, and berries by those who understand the process. Among ancient and primitive peoples there were infinite ways of mixing and blending the different coloring materials to produce the tones desired, the recipes, or formulas, being guarded as precious secrets in the family of the discoverer. When our Colonial grandmothers spun and wove the cloth for their clothing and household linens they used these natural dyes for the colors they wished, the children usually gathering the branches, berries, or roots containing the coloring matter to be used. The soft reds and blues that we find in the wonderful old hand-woven coverlets, as well as the many duller tones of purple, yellow, green, and brown that still remain in old carpets or braided rugs, are colors that these women probably extracted from the trees and bushes in their own locality.

2. *Artificial dyes.* The natural dyestuffs were the only coloring materials used by anyone in the world until sixty or seventy years ago, when an entirely different class of colors was discovered, which have since largely replaced the natural dyes. These are the artificial dyes that are manufactured from coal tar, a by-product obtained in making coke. Since the discovery of these dyes by Sir William H. Perkin in 1856, chemists of all countries have been experimenting in the development of new colors. With her methodical habits and her tendency for research work, Germany, up to the time of the World War, had become the leading producer of coal-tar dyes, and the countries that had depended upon her for their dyestuffs suffered much inconvenience in the early years of the war. During those years the United States was thrown upon her own resources for producing dyes, and the effect of inexperience was quickly seen. Many familiar colors could not be found at all in the cloths we bought, and both manufacturers and retailers flatly refused to guarantee the fastness of their colors. Black stockings were a particularly sad investment in those days. Since 1914 the dyestuff situation in the United States has changed greatly. There are now several large plants turning out American dyes which are in every way as satisfactory as the German dyes.

The coloring of cloth by dyeing means its complete immersion in a color bath, so that every part shall come in contact with the coloring matter. In well-dyed goods each individual yarn is evenly colored, and, unless afterwards printed, the face and back of the material are the same color. The chemical composition of the dye liquor, the strength of the color, the temperature of the water, the length of time the cloth shall be kept in the dye bath, and the succeeding treatment of the material are all problems that must be worked out by the trained chemist or dyer before the dyeing operation begins. Satisfactorily dyed materials are those

with clear, even color of desired tone, which neither crock nor "bleed" and will remain unchanged under usage.

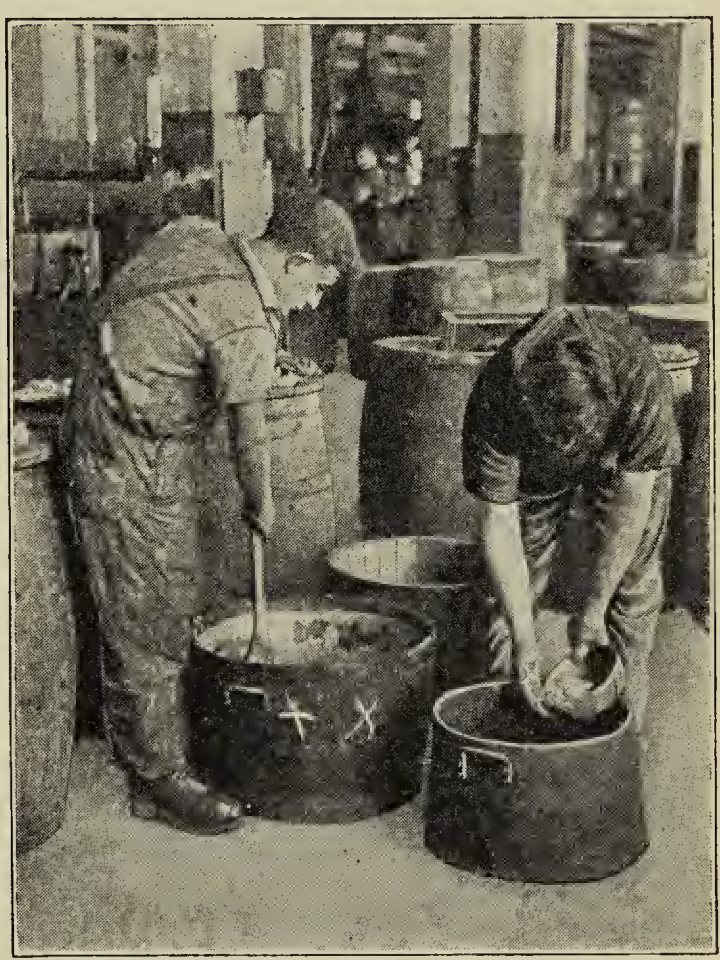
Fastness of color. Colors which remain the same during the life of the cloth are called fast. Fastness of color does not mean that it will remain permanent under all conditions, but it does mean fastness to the conditions that the cloth would ordinarily encounter. For cotton materials like shirting, denim, cloth for house dresses, aprons, and children's rompers, where frequent launderings are necessary, the dye is made fast to washing. For chambray, gingham, poplin, and other cotton dress fabrics, as well as for draperies and curtain materials, for linen suitings, wool dress goods, and silks for dresses and outer garments, the dye is made fast to sunlight. Umbrella silk, some dress silks, and many wool goods are made fast to water spots. The name *shower-proof foulards*, used by one well-known silk manufacturer, expresses this distinguishing characteristic. Some materials which are produced especially for long, hard wear are made fast to perspiration. Government specifications for army cloth require that it shall be fast to several conditions, among which are sun, water, and perspiration.

Essential factors in successful dyeing. The coloring elements in dyestuffs do not have an equally strong affinity for all kinds of fibers. There are dyes that will color silk and wool but that have almost no effect upon cotton and linen, and vice versa. The chemist must know not only the nature and quality of his dye but also the nature of the material to be dyed and its reaction to dyestuffs. Thus the problem of the dyer is by no means a simple one.

1. *Clean fabrics.* While a complete understanding of the dyeing operation necessitates a knowledge of chemistry, there are a few practical principles that greatly influence successful dyeing. All materials must be perfectly clean (free from dirt, grease spots, natural gums, or oils) if they are to take an

even dye. Cloudy or spotted places in colored fabrics mean carelessness in either the washing or the dyeing operations.

2. *Pure water.* For a clear, even color clean, pure, soft water must be used in the dyeing process. One reason why mills sometimes have to send their gray goods a long distance to some dyeing or bleaching plant is because the water near their own plants is not suited to these operations. New England is fortunate in having good water as well as other advantages for textile manufacture; hence many bleaching and dyeing plants are found there.



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MIXING THE COLORS FOR DYEING

3. *Right dyes.* The dyestuff must be of such a nature that the coloring matter will unite with the fiber, producing any strength of color desired, and must be set, or fixed, so that the goods will not bleed or crock. Silk and wool materials dye more readily than cottons and linens. These last two fibers frequently require another chemical, called a mordant, to make a permanent union with the dyestuffs, and even then the colors are not always guaranteed to be fast. In washing colored cotton and linen materials a good laundress uses care and usually sets the color before washing.

4. *Thorough rinsing.* The last but not least essential factor in successful dyeing is a most thorough rinsing. (Here again pure water is a necessity.) In home dyeing the instructions read: "Rinse until the water remains clear." If this rule were always strictly adhered to in commercial dyeing, our stockings would not crock when worn nor bleed when washed. Thorough rinsing of dyed materials not only removes all extraneous dyestuff, so that the material is a clear color when dry, but it also shows whether or not the dye has been properly set in the fiber. As every extra handling of cloth adds to its expense of manufacture, however, it is no wonder that the coloring in low-priced dyed materials is inferior in both appearance and wear to that in fabrics of a better quality.

Topping. Sometimes cloth is dipped several times if, upon examination, it is found that the yarns are not fully dyed or the color is not strong enough. Sometimes the color is not right, and it may be dipped into a bath of another color to produce the right tone. This is called topping, and beautiful colors are produced in this way.

Cross dyeing. To obtain a plain color in a cotton-and-wool mixture the cloth is sometimes dipped into two baths of the same color, each of which dyes only one kind of fiber. This is called cross dyeing. Sometimes in a cotton-and-wool mixture the cotton is dyed in the yarn, and the woven material is then immersed in a wool dye of the same color. This is also called cross dyeing. This method of dyeing may take place in any fabric made of the two classes of fibers (animal and vegetable), as silk and cotton, silk and artificial silk, wool and artificial silk, etc.

Yarn dyeing, or skein dyeing. Yarn dyeing, or skein dyeing, is a very popular method of coloring and for certain materials is absolutely necessary. It is yarn dyeing that allows

the introduction of many colors in the same piece of goods and gives our limitless variety of stripes, checks, plaids, figures, borders, two-toned effects, etc. that are found in such quantities in all sorts of materials. In yarn dyeing cleanliness of material is as important as in piece dyeing. The colors in yarn-dyed goods can be made fast to the conditions required, and usually both sides of the cloth are alike.

Stock dyeing. Stock dyeing, or the dyeing of the raw material, is required for certain classes of dyed goods. "Dyed in the wool" is an old saying which means the acme of thoroughness. In stock dyeing every individual fiber of the raw material is subjected to the action of the dye and becomes thoroughly colored. In stock-dyed materials pulling, tearing, or straining of the goods causes no exposure of undyed fibers. For yarns of mixed colors (as tweeds) and of mixed fibers (as cotton with silk, cotton with wool, worm silk with artificial silk) stock dyeing is desirable and the same principles of cleanliness hold good.

Piece dyeing. Piece-goods dyeing is the most popular form of dyeing. If accurately done it produces materials of plain, even color with both sides alike. It is a quick, easy, and inexpensive method, and as it is done just before the final finishing processes the color is kept clean and bright.

QUESTIONS AND ASSIGNMENTS

1. Give the names of three well-known commercial dyes for use at home. What cautions are given in the directions? For what particular purpose is soap dye suited?

2. Get samples or articles of linen in the different bleaches and compare them as to price, use, and durability.

3. What is meant by "setting colors"? The following are general directions for setting colors in cottons and linens:

Use cold water, allow to stand overnight, then *let the article dry* before washing.

To set pink, brown, black, or black and white:	Use 2 cups salt to 1 gal. water.
To set blue, green, or mauve:	Use ½ cup strong vinegar or 1 tablespoon alum to 1 gal. water.
To set lavender:	Use 1 tablespoon sugar of lead to 1 gal. water.

What other methods have you known to be employed? When is the best time for setting colors in materials to be made up at home?

4. What care should be taken in the drying of colored clothes? in the ironing?

5. To how many conditions should the colors in gingham be fast? Get three pieces of gingham, test them in the following ways, and compare with new samples.

a. Wash three times without setting colors.

b. Lay sample outdoors in the sun and let it remain there a week.

6. Under guidance of the teacher the class should make Javelle water and use it to bleach some article that has grown yellow.

Javelle Water

½ lb. chloride of lime	1 qt. boiling water
1 lb. washing soda	2 qt. cold water

Pour boiling water on washing soda and let stand until dissolved. Stir chloride of lime and cold water until dissolved. When settled, pour into soda solution.

7. With one of the common commercial dyes do one piece of dyeing. Write out an accurate description of your process.

8. Topping is an interesting process, as the color of an article can be completely changed by this method. Do one piece of topping, either by dyeing a fabric twice or by redyeing one that has previously been dyed. Write the result of your experiment with any of the following combinations:

Blue over red produces purple.
Blue over yellow produces green.
Blue over brown produces deep seal brown.
Blue over purple produces blue-plum color.

Blue over green produces bluish green.
Light blue over green produces peacock blue.
Light blue over pink produces lavender.
Light blue over orange produces brown.
Red over dark green produces brown or black.
Red over blue produces purple.
Red over yellow produces scarlet.
Red over heliotrope produces wine color.
Red over orange produces scarlet.
Red over green produces brown.
Cardinal over navy blue produces light purple.
Maroon over dark green produces plum color.
Maroon over navy blue produces dark purple.
Yellow over red produces scarlet.
Yellow over blue produces green.
Yellow over brown produces golden brown.
Yellow over purple produces dull green.
Yellow over green produces light green.

9. Name one large American bleaching and dyeing plant.
10. Collect labels guaranteeing the dye in materials.

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See page 369.

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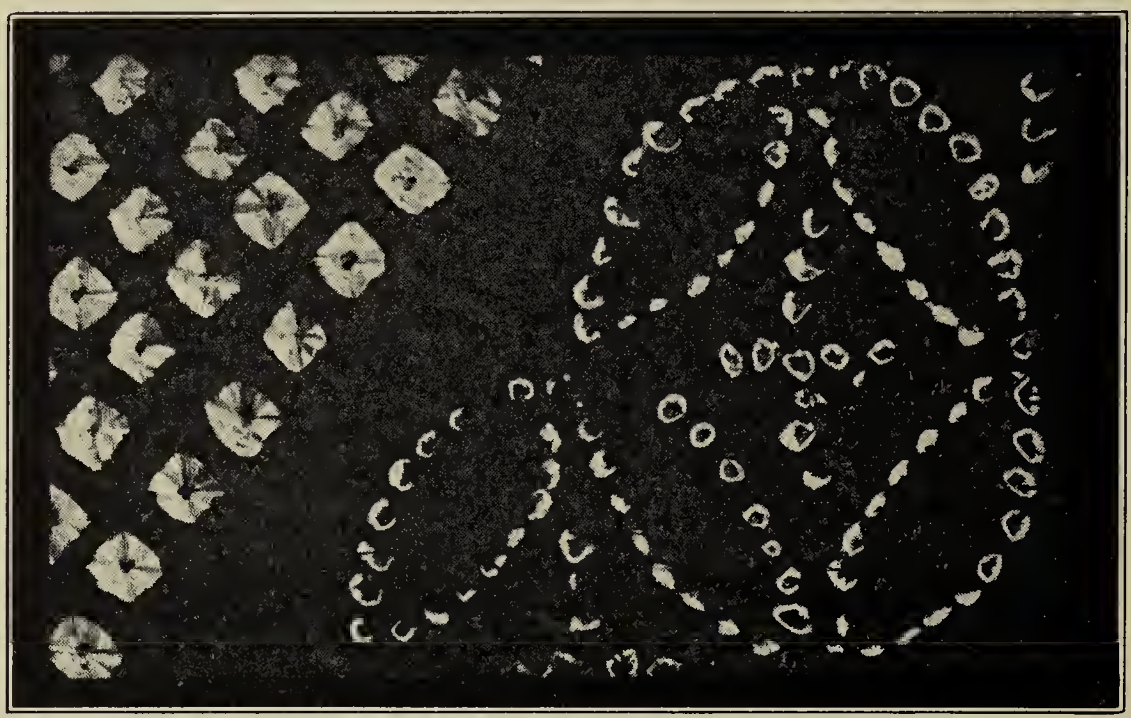
CHAPTER IX

COLORING AND FINISHING OF CLOTH: PRINTING

Colored designs in cloth. 1. *Dyed patterns.* The application of color to cloth is a very old process, and dyeing, or dipping the material into the color solution, is the simplest and perhaps the oldest method. As we have seen in the previous chapter, piece dyeing gives no variation in color throughout the length of the cloth. One method of obtaining a design in dyed goods is to color the yarn first and produce the pattern by the mathematical arrangement of the yarns in weaving. (The exception to this mathematical accuracy is the common "hit-or-miss" pattern of rag carpets, where the filling yarn is made of rags of various colors and lengths sewed together with no accurate knowledge of the combinations to be brought out in the weaving.)

a. Yarn-dyed patterns. Beautiful effects in woven goods are produced by the use of colored yarns; but, while many colors may be employed, the variety of patterns in yarn-dyed materials is somewhat limited, and in our common fabrics is usually confined to stripes, checks, and plaids. Ginghams, Devonshire cloth, bed ticking, awning cloth, and striped and plaid suitings and coatings illustrate the multitude of changes that can be worked out in these fundamental patterns. If individual figures are desired in yarn-dyed goods, they are usually of geometric forms, as shown by the squares, triangles, stars, and circles often found in shirting madras and sometimes in cretonne and fancy voile. There are wonderfully elaborate naturalistic and conven-

tionalized patterns in hand-woven tapestries and in some of the machine-woven imitations; there are also beautiful designs in silk brocades for gowns, neckties, trimmings, and linings made by the use of dyed yarns; but the process of producing these elaborate patterns by weaving is expensive and is not much employed in low-priced materials.



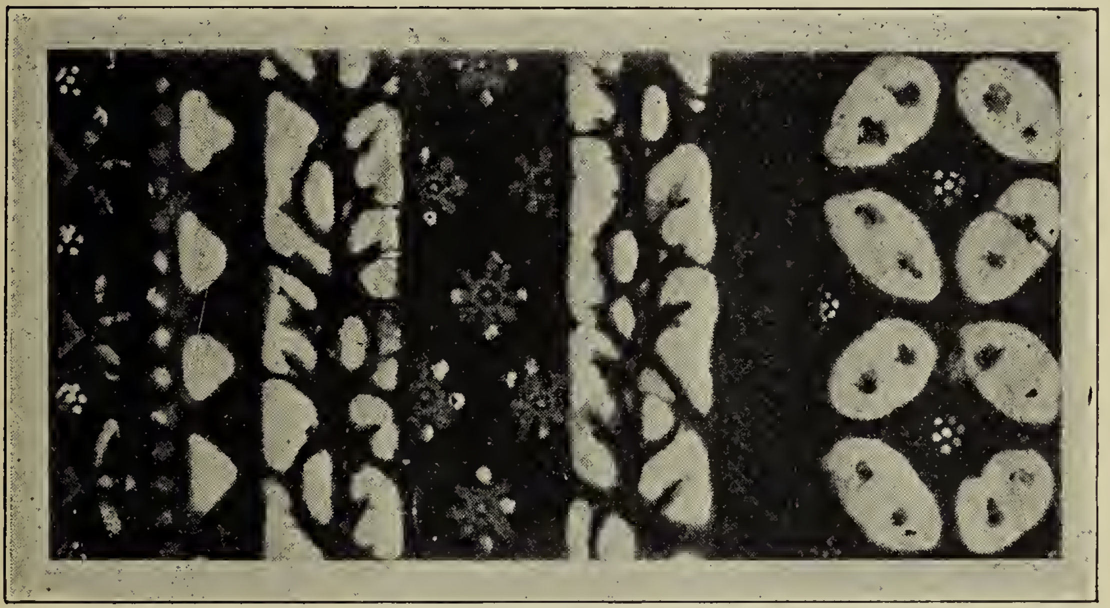
A TIE-DYED PATTERN

Each of the white spots was tied with string before the cloth was dyed

b. Tie-dyed patterns. Primitive people employed unique methods to obtain a variety of patterns in dyed materials, and their methods are much practiced by art students of the present day. The product of one method is known as the "tied and dyed" or "tie-dyed" work and probably originated in India. In tie-dyed materials certain places in the undyed cloth are picked up and string or tape is wound so evenly and tightly around these spots that no dye can penetrate to them, and the entire piece of cloth is then dipped in the color bath. Sometimes, if an elaborate effect is desired, many spots are tied and the cloth is dipped several times,

some of the spots being untied or new ones tied before each dipping. Finally only a few spots are white, while the blending of the different colors in the others produces a wonderfully artistic effect. The production of patterns in this way is a slow process, requiring much knowledge of color combinations, and, needless to say, is little used commercially.

c. Batik work. The beautiful batik work sometimes found among the choice bits of decoration in our homes, and



A JAVANESE BATIK

occasionally seen on artistic smocks, blouses, and negligees, and in such costume accessories as neckwear, bags, scarfs, and handkerchiefs, is another attempt to produce elaborate patterns by means of the dyeing process.

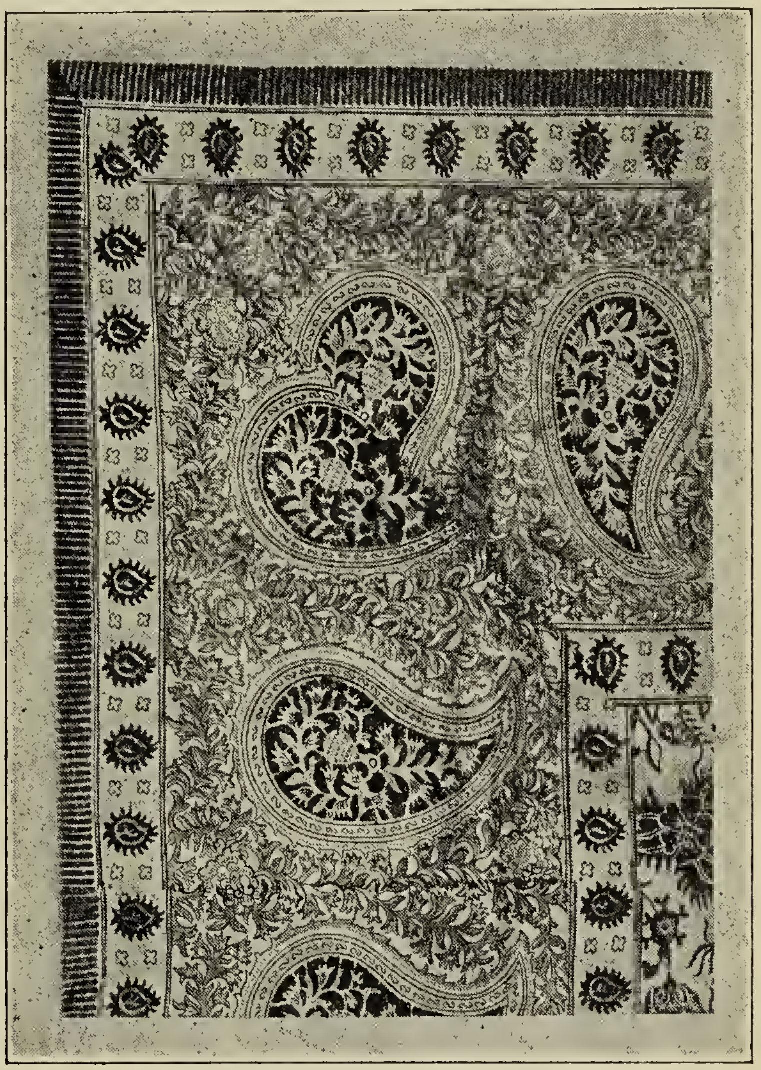
The natives of Java are believed to be the originators of the batik method of coloring, and it is still used on that island. The real Javanese batiks are always of cotton, and the colors mostly used are indigo blue, a reddish or chocolate brown, rich reds, and tones of yellow. The principle of batik coloring is the same as that used in tie-dyed work,—the making of certain parts of the cloth resistant to the dye into which it is dipped. In tie-dyed work the spots are made

resistant by a covering of string; in batik work the design is drawn on the cloth and the parts which are to remain uncolored are made resistant by a covering of wax. Only simple patterns can be produced in tie-dyed work, while in batik work the intricacy of the design is limited only by the imagination or ability of the producer. As in tie-dyeing, the number of times the cloth is to be dipped in the dye depends upon the number of colors in the batik design, so the resistant wax is removed or applied in different places before each dipping. Sometimes the wax cracks while in the dye bath, and little lines of color seep through onto the protected spot, causing a crackled appearance. This effect is considered bad workmanship by the Javanese but is thought very artistic by the American people. Perhaps none of the ancient decorative arts is more engaging to present-day artists than batik work. Wonderful designs in gorgeous colors on exquisite silk materials can be produced by the batik process, and nearly every art student attempts some of this work. Batik work is more often found in retail stores than tie-dyed work. In many mercantile houses where high-class goods are carried, talented artists are employed to produce individual patterns for the customers. Batik designs are frequently copied in commercial printing.

2. *Printed patterns. a. Block printing.* Another old method of producing figured materials was to apply color to the surface of the cloth instead of dipping the whole piece. This was the process employed in the coloring of tapa cloth, and striking designs may be seen on pieces of this material now preserved in our museums. To apply the color, a design was carved in a block of wood, which was then dipped in the color mixture and stamped on the cloth. This is called block printing, and is employed among primitive people at the present day. Block printing is used by the people of India with their fine cottons, and very elaborate patterns are still

produced by this method of coloring. Block printing is also a favorite practice with artists, as original designs can be used, making the fabric impossible of duplication. Block printing, however, like tie-dyed and batik work, is an artistic achievement rather than merely a commercial process.

b. Roller printing. The simplest and at the same time the most amazing method of producing figured patterns on cloth is by roller printing. That is the method used in coloring many of our attractive figured drapery and dress materials. Only by this wonderful process of stamping color on cloth are we able to find such a variety of dainty and striking designs in foulard, percale, flaxon, and calico for garments, and in chintz, cretonne, terry cloth, etc. for hangings. Most of our colored cotton fabrics are printed, as are many of our silks. Sheer linens, as figured handkerchief linen, and light-weight wool materials, as challies, are printed.



BLOCK PRINTING DONE IN INDIA

Note the poor matching of the pattern at the corner and near the lower edge of the picture

The printing process. Of all the processes of textile manufacture, perhaps printing is the most fascinating. By textile printing we mean the stamping of a pattern in color by machinery on one or both sides of a piece of cloth, as was formerly done by hand in the old block-printing method. The color is applied, not by wooden blocks, but by copper rollers or cylinders, and the cloth must be in the right condition to receive the color from these cylinders without blotting or running. It must be absolutely clean and its surface entirely free from fuzz or fiber ends. Cloth is usually bleached before being printed. Regardless of the number of colors or intricacy of design, the entire pattern is stamped upon the cloth in one operation. This marvelous feat is accomplished by running the cloth through a printing machine which contains the copper cylinders we have mentioned, each of which deposits a color on the material as it passes through the machine. Therefore, if the pattern is to contain three, five, seven, or twelve colors, there must be that number of copper cylinders in the printing machine that does the work. There are machines at the present time that will print sixteen colors.

1. *The copper cylinders.* Unlike the printing of newspapers, where the face that does the printing projects from the surface of the printing press, the pattern that prints the color in cloth is engraved or etched into the surface of the copper rollers. These rollers are long enough to extend across the width of the cloth to be printed, and their preparation is a wonderfully interesting operation. After the design to be used has been decided upon and worked out on paper with the chosen colors, it is photographed and enlarged many times. This brings out every minute detail of the pattern so that it can be corrected and easily reproduced on a zinc sheet, which is the next step in the process. After the design in its enlarged size has been drawn on the zinc sheet, it is taken by

a man called a graver, and every line is permanently cut into the zinc. The next process is to paint the colors on the zinc sheet, and there is then a large, clear, permanent picture of the pattern. This zinc design is then placed in a machine called a pantograph, by means of which it is transferred directly to the copper rollers that are to do the printing.

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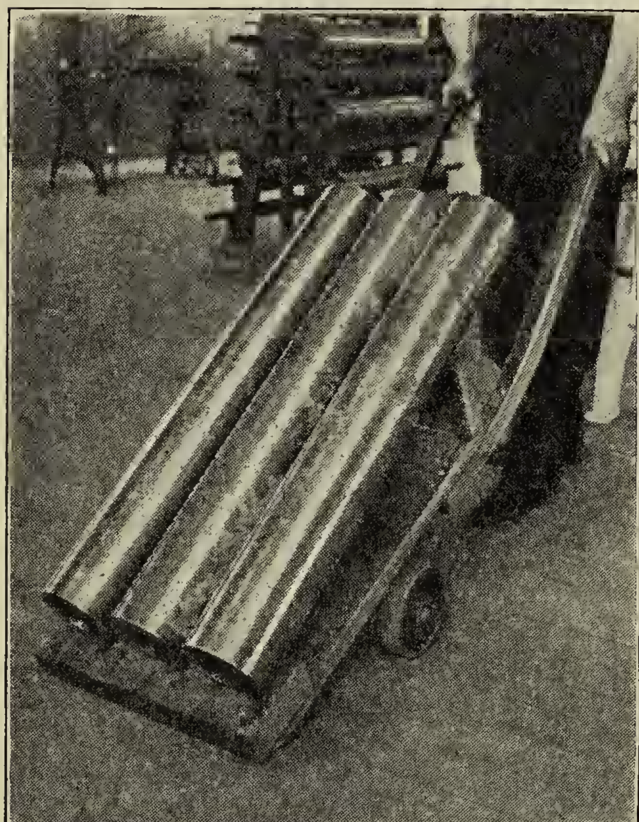
THE PANTOGRAPH

The roller that is being etched can be seen near the top of the picture

2. *The pantograph.* To a person unacquainted with the pantograph it seems a most marvelous machine. At the top of the pantograph is placed one copper cylinder covered with a coat of varnish, and almost touching it are arranged diamond-pointed needles for cutting the pattern in the varnish. This cylinder is to carry one color of the dye or paint, so there are as many of these diamond points as there are to be repetitions on the cylinder of the one color in the pattern. The enlarged zinc pattern is placed on the table of the pantograph directly in front of the operator, and she traces with a pointed instrument along all the grooved lines of one color. Now the wonderful mechanism of the pantograph is shown, for as the operator traces the

enlarged pattern she presses with her foot a lever which controls the small diamond points, and each etches into the varnish of the copper cylinder the same design reduced to normal size. So, by one tracing of the enlarged unit of the pattern by the operator there has been transferred to the printing roller or cylinder the exact number of duplications of the pattern in their proper order and arrangement and in their original size. The cylinder is then immersed in nitric acid long enough to eat into the copper where the varnish has been cut, and leave a permanent impression on the cylinder.



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ETCHED ROLLERS

Each color unit in the design is transferred from the zinc plate to a copper roller in this way by the pantograph, the number of rollers required for any pattern being governed by the number of colors in the design. Some cloths, such as elaborate cretonnes or kimono silks, may contain as many as twelve colors, and twelve copper rollers must be engraved to do the printing. These cylinders are very pretty after the pattern has been etched by the acid, as no two are alike, there being only a few engraved places on the surface of some, while others are nearly covered.

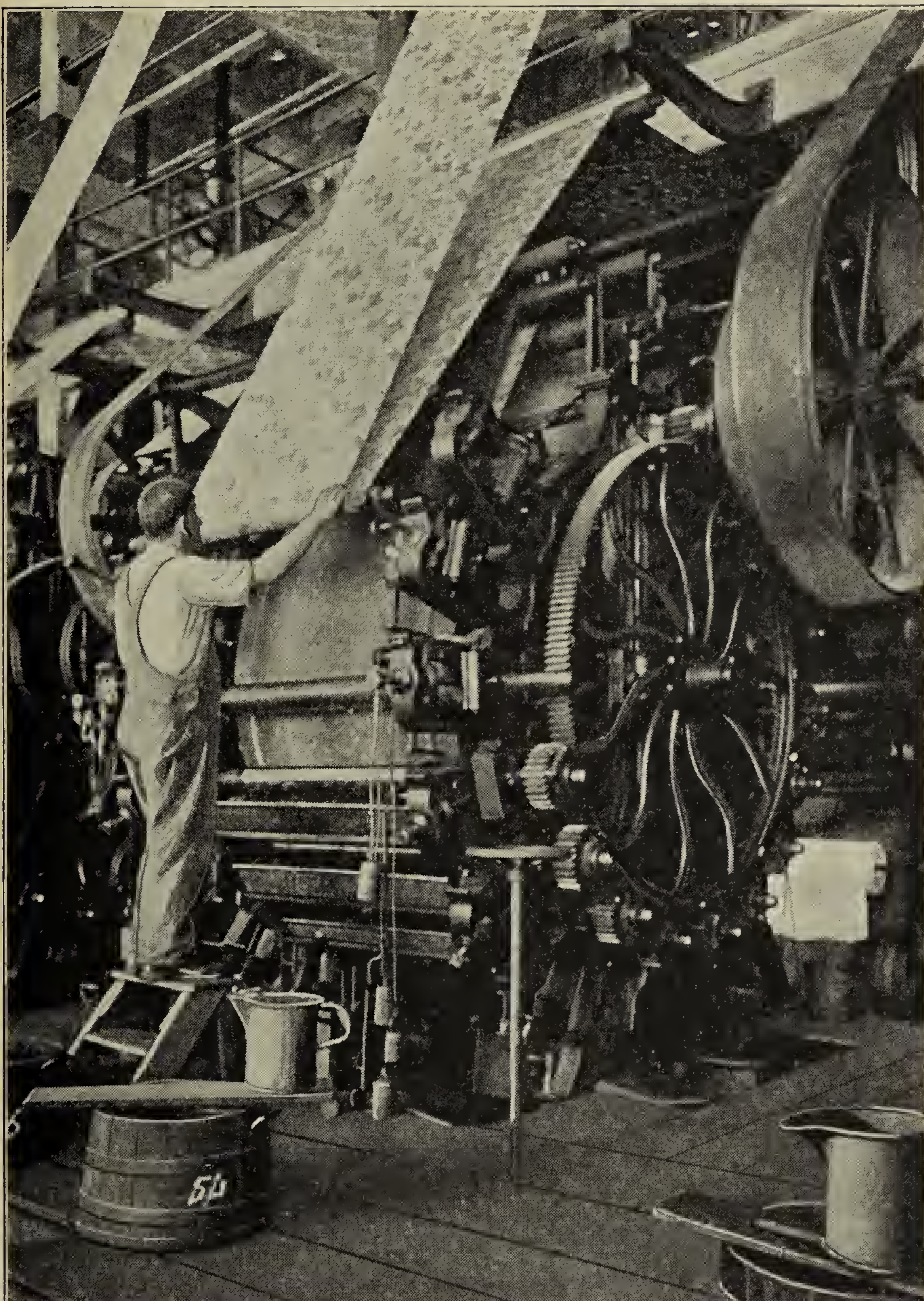
3. *The printing machine.* The engraved rollers are next accurately arranged in the printing machine, each with a pan

of dyestuff (the color for that particular part of the design) placed under it. The cloth to be printed is arranged in the machine over a big padded drum behind the rollers. The whole machine is then set in motion, all the rollers turning at the same rate of speed in order to fit the parts of the pattern together correctly, and the cloth traveling at a rate that will allow it to receive a perfect impression of the entire set of rollers. As a roller turns and its surface becomes covered with its color a finely adjusted instrument called a doctor knife scrapes off all the dyestuff, except that which remains in the engraved indentations, before the roller comes in contact with the cloth. It is interesting to examine any high-grade piece of printed material and see how exactly the colors in the different details of the design fit together. As we stand before a printing machine and watch the gray or bleached cloth enter and travel along behind the engraved rollers, receiving spots of a different color from each roller as it passes, until in a few seconds it leaves the printing machine a beautifully colored fabric, it seems as if some fairy magician must have waved his wand to cause such a wonderful transformation.

4. *The setting of the colors.* The setting of the colors, which is the next step in printing, contains none of the romance of the processes already described, but is equally important in the production of satisfactorily printed materials. As in the case of dyeing, the colors are made fast to the cloth in various ways. Printed cottons are usually run over very hot rollers or subjected to live steam, to set the colors. Sometimes printed materials are washed, and again they may be treated with a chemical bath. Whatever the means employed in setting the colors in printed materials, the processes must be guided by people of skill and intelligence, else all the delicate operations already performed on the cloth are rendered valueless.

This very brief description of printing, showing the wide knowledge and expensive apparatus required to produce printed cloth, gives us some idea of the cost attached to the process. Each color must be right in every way, since, although it is possible to correct or improve the hue in dyed materials, the color stamped on fabrics by printing must remain permanent. The machines must be flawless in their mechanism, as any fault in their operation is instantly registered on their product. The operators must be trained and reliable people who know how to use and control the machines with which they work, so as to get from them the best and greatest possible production. Because of the expensive machines and the highly paid employees, a vast amount of money is required to establish and run a textile-printing plant.

Rapidity of production in roller printing. How, then, we may ask, is it possible for printed cloth to be produced and sold at the low price for which we buy it in the stores? Before the World War cheap calico or print could be bought for 4 cents a yard, and, though it may never return to pre-war prices, it will probably always be found for a few cents a yard in our retail stores. How can this be done when we realize the expense connected with the printing process? The answer is found in the rapidity with which the printing is accomplished, and therefore the great amount of cloth that can be printed in a given time. One manufacturing plant that advertises the largest print works in the world states that 500 miles of cloth are finished and packed ready for shipment from its factory each day. With such a rate of production the large investment of money in high-type machines and intelligent and highly trained employees who will produce few "seconds" can be made profitable, and the printing cost of each yard of cloth can be reduced to a very small figure.



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A PRINTING MACHINE

Duplication of patterns. We are not surprised, therefore, to find a great many duplications of patterns among printed goods. Exclusive designs in printed fabrics astonishingly increase their cost. Great variations can be made by changing the colors in the different parts of the design, however, and this is commonly done in printing. In cretonnes particularly we may find one bolt where yellow is the predominating note, with all colors in the minor parts of the design made to harmonize with the yellow hue of the cloth. Another bolt of exactly the same design may be worked out in red values, or blue, or green. The same design could probably be found worked out in just the neutral tones of black, white, and gray, and so on. An endless number of differences in printed cloth may thus be brought about simply by changing the colors in the little troughs under the engraved copper rollers.

Duplicate printing. Occasionally we find cloth with a pattern, which may be more or less elaborate, equally distinct on the face and back. The cloth has the appearance of being yarn dyed, but the pulling out of a yarn shows it to be printed, not dyed. In thin materials, like light-weight silks and very thin and sheer cottons and linens, the color may "strike through" the cloth in printing, but the selvage of such materials will usually show which is the face of the goods. For some purposes it may be desirable to have the distinct pattern on both sides of the cloth, and both the face and the back of the cloth are printed. This is called duplicate printing. Drapery materials, such as terry cloth, are usually colored in this way. When the pattern on the face and back match so perfectly that a pin stuck through the cloth will hit exactly the same part of the pattern on both sides of the material, it is called duplex printing. Duplex printing on cloth is usually a very close imitation of yarn dyeing, and frequently the difference can be discovered only by examining an individual yarn.

The resist method. Another very interesting way of producing color on cloth is by a combination of dyeing and printing. There are two common methods by which patterns are produced by this combination of processes. They are known as the "resist" and "discharge" methods. In the resist method the same principle is used as we found in the tie-dyed and batik work; a part of the cloth is made resistant to color. In the commercial resist process, however, no painstaking handwork is required, for these same copper rollers that we have seen used for stamping color on cloth can be used just as successfully for stamping the resist wax on cloth. For resist dyeing the white cloth is run through the printing machine, where the pattern is stamped on in resist paste, which prevents the design from taking the color when the cloth is immersed in the dye bath. After the cloth has been dyed, the resist paste is removed and a white pattern appears on a plain colored ground. The small white figures or patterns on many of the plain red, blue, black, or gray grounds in some of our inexpensive percales, calicoes, or prints may be produced in this way. The laundering qualities of these goods are usually excellent, as the dye has thoroughly colored the material and been permanently fixed, or set.

The discharge method. The same effect in printing can be produced by the "discharge" method, and this is the more frequently used. In the discharge method the cloth is first dyed, and is then put into the printing machine, where these same engraved copper rollers print upon its surface a pattern in a chemical mixture. By the proper after treatments of the cloth this chemical completely takes out, or discharges, the color wherever it has been applied. In this way a white pattern on a dyed ground is produced, as in the resist method. The after treatment of the cloth in discharge printing must be intelligently done, as the strength of the chemicals

used may tender the cloth, and the spots will drop out with use, as sometimes happens. Goods colored by this method also launder well.

We occasionally find small figures in color on a plain dyed background, and we wonder how they can be produced. To our surprise we find that they can be produced by either the resist method or the discharge method of printing, and again we appreciate the knowledge of the color chemist. It is possible to print resist or discharge *colors* onto the woven cloth so that the after treatment will produce a pattern,—not in white only, but in any color or combination of colors.

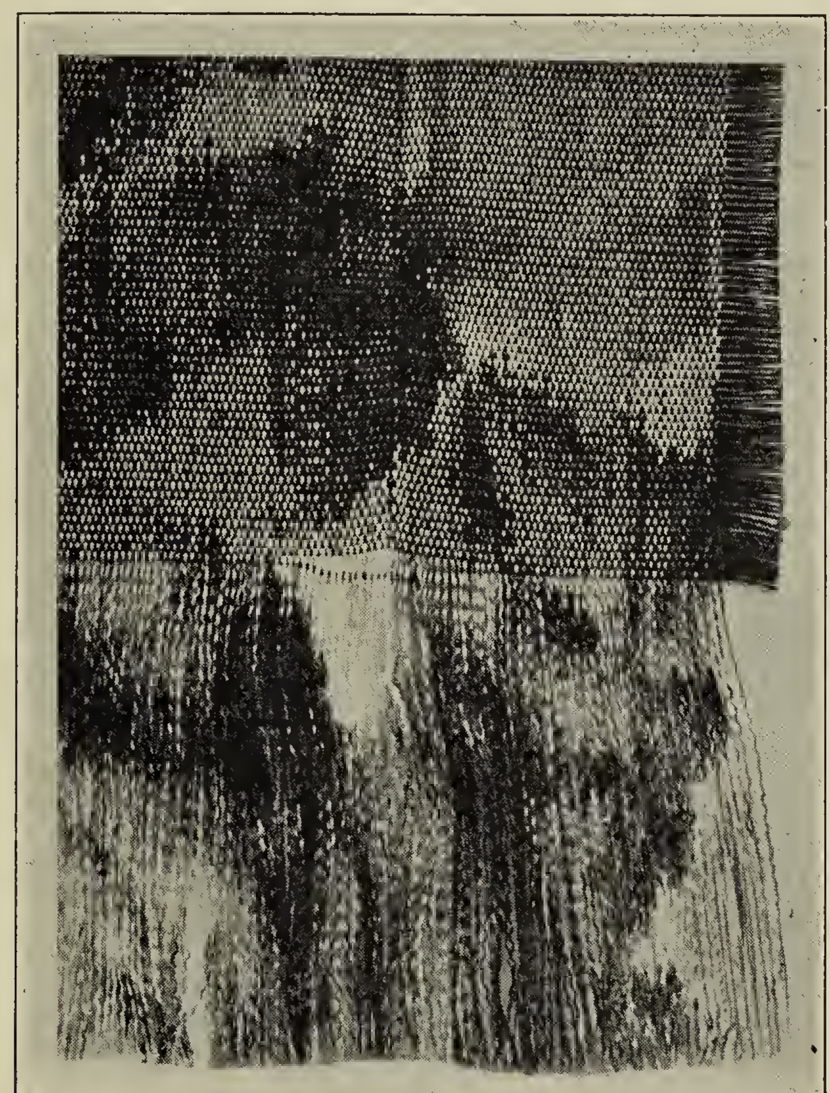
Composition dots. Some cloths are decorated by the permanent application of white or colored paste to the face of the cloth. The figures of paste are called composition dots and are not usually applied to wash goods. Here again the copper rollers have been employed, this time carrying adhesive paste instead of dye in their indentations.

Yarn printing. Printing is not always done on the woven cloth. For some effects bars are printed across the yarn in the stage of slubbing. The succeeding drawing out and doubling processes in the making of the yarn produce a most satisfactory color. In tapestry Brussels carpets and figured chenille hangings the pattern is produced by the printing of the yarns.

Warp printing. Sometimes we see goods advertised as warp-printed silks or warp-printed cretonnes, and we wonder what the term means. These cloths are usually very effective, the indistinct outlines of the figures blending into each other, making the whole color scheme soft and subdued. If we ravel out some of the filling yarns we find they are of one plain color, while the design of the cloth in bright colors and sharp detail is seen on the warp yarns. In this case the pattern has been stamped by the engraved rollers on the arranged warp ends before the cloth was woven. By

varying the color of the plain filling yarns, many different effects can be produced on the same printed warp ends.

There are countless other methods of producing printed materials, that have not been mentioned here. It seems as if



WARP-PRINTED CRETONNE

Note pattern on warp yarns

there were no limit to the multitude of designs, the number of color combinations, and the variety of methods that may be employed in the coloring of cloth. With our constantly changing styles, the artist and the color chemist have a wonderful field for creative work in the textile world.

QUESTIONS AND ASSIGNMENTS

1. Name ten kinds of cloth that are printed. Bring samples.

2. Bring a sample of cloth that you think has been dyed by the resist method or by the discharge method and give the reasons for your opinion. Bring a sample of warp-printed material.

3. Why is printing found more commonly among cottons than among other classes of cloth?

4. What wool material is always printed? What silk material?

5. Collect labels that give information about the method of coloring or the endurance of the dye in any piece of cloth or article of wearing apparel.

6. Find and examine a specimen of batik coloring. Have you ever seen the process of batik printing?

7. Test three pieces of printed materials for fastness to sun and washing, according to the directions given for ginghams in Chapter VIII. What colors seem the most enduring?

8. What is the difference between Devonshire cloth and galatea in respect to the method of coloring? Do you know whether or not there is any difference in the fastness of color of the two materials?

9. Name five yarn-dyed cotton materials. What about the fastness of the colors in these cloths?

10. What care should be given to printed materials in the laundry?

11. Do one piece of tie-dyed work.

12. Make a design for a printed fabric.

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CHAPTER X

COLORING AND FINISHING OF CLOTH: MERCERIZING AND FINISHING

What a multitude of differences there are among cloths! Some of these differences are fundamental and are caused by the kind of weave or stitch employed, the size or structure of the yarn used, the bleaching or coloring given to the cloth during its process of manufacture, or the kind of raw material of which the cloth is made.

Varying effects on cloth of the finishing processes. There is still another class of operations in the making of cloth, and by its employment two pieces which, in weave, yarn, color, and kind of raw material, were exactly alike when taken from the loom may, when ready to be sold, so differ in appearance that they are sold under different names and are used for different purposes. Take, for example, some of our broadcloths. After being woven, and before anything else is done to them, they closely resemble flannels in the same stage of manufacture. Behold the difference between the two cloths when we buy them! Probably the average person could not tell canton flannel, when just woven, from certain grades of duck or khaki in the same stage. But who would confuse the two classes of cloth in the store? Outing flannel and serpentine crêpe are, when taken from the loom, plain cotton materials instead of fuzzy and crinkly fabrics, as we know them, while the cloths that you and I buy as nainsook, batiste, longcloth, and cambric may have been produced from identical pieces from the loom.

Again, cloths that are vastly different in appearance when woven may, when we see them side by side in the store, appear to be the same thing. When taken from the loom, some poplins and reps made from cotton resemble the silk materials of the same name only in their weave. Yet when the cotton poplin is seen in a skirt or gown it could easily be taken for silk. Certain kinds of cotton knitted underwear so closely resemble silk as to confuse the ordinary purchaser; while cotton damasks, which may be without a vestige of luster at the time of weaving, may develop such a sheen, by the time they are displayed for sale in the linen department, as to deceive the keenest observer. Thus important changes may be brought about in the appearance of cloth in other stages of its manufacture than those already studied, and the various operations which cause these striking changes are included in what are called the finishing processes in cloth making.

The finishing of cloth consists, as the name implies, in applying the final treatments to the woven or knitted materials before they are put into the hands of the buying world. There are two main objects in the finishing of cloth: one is to increase its beauty; the other is to increase its adaptability to the purpose for which it is intended. Bleaching, dyeing, and printing all belong to the finishing processes, but the final operations that follow these are usually what make fabrics distinctive.

Mercerization. Of all the finishing operations the one that causes the most surprising and the most permanent change is the mercerization of cotton materials. Have you ever been deceived into thinking that a certain sweater was all silk, and then discovered that it was made wholly or partly of mercerized cotton yarns? Some mercerized cotton stockings so closely resemble silk as to make a very satisfactory substitute. Much domestic shantung and pongee contain

mercerized cotton yarns, and in the field of trimmings, braids, cords, fancywork materials, and novelty fabrics there is no end to the ways in which mercerized cotton is employed.

The process of mercerization is one of the most interesting modern discoveries in the textile world. It is of comparatively recent date, having been generally used only during the last twenty or thirty years, although the principle of mercerization was discovered by John Mercer. The story goes that, unlike most inventions and discoveries connected with cloth making, the discovery of mercerization was an accident. John Mercer was a calico printer of Lancashire, England, and used caustic soda in the preparation of his goods for printing. One day the cloth was immersed in a caustic-soda bath much stronger than was intended, and when removed it was found to have shrunk considerably and to be somewhat changed in character and appearance. Fearing that he had lost his cloth, Mercer began to examine the material closely and found that it was not destroyed, as he at first feared, but had attained certain new characteristics which were advantageous. It would take and hold dye better than before; it seemed smoother and more translucent; and, to his great amazement, it was actually stronger than before the accident occurred. Microscopic examination of the individual cotton fibers showed that a great and permanent change had taken place.

The cotton fiber in its natural state is a twisted, flattened cylinder. Picture to yourself a collapsed fire hose that has become badly twisted and you have a very good illustration of a ripe cotton fiber. The cotton fiber is short, ranging from ½ inch to 2½ inches in length, and this curly, twisted structure greatly aids the spinning process. It is, however, this singular structure that makes cotton goods fuzzy and prevents it from having a sheen, or luster. The effect of the caustic soda is to swell, or plump up, these flattened cylin-

ders; and if the fibers are stretched at the same time, they lose much of their twist and curl and become more nearly like straight, translucent rods which reflect the light as do the straight fibers of silk and flax.

The mercerizing process. Mercerization is an expensive process, and it could not be made commercially profitable for a long time after John Mercer discovered it. That is why we find no mercerized materials among the beautiful old underwear or "linens" of our grandmothers. As mercerization increases the cost of manufacture, it is usually employed with a high grade of cotton fiber and is put into well-made materials that will sell for a good price. Mercerized fabrics, therefore, are not only more beautiful but stronger and more durable than their duplicates which are untreated by this process. Mercerized damasks, mercerized knitted underwear and stockings, mercerized batiste and nainsook, mercerized shirting and pajama cloth, mercerized reps and poplins, are more expensive, but also more satisfactory, than similar fabrics made without this chemical treatment. Mercerization is frequently done in the yarn; but whether done in the yarn or the piece, the steps in the mercerizing process are similar. Goods to be mercerized must first be thoroughly cleansed and boiled to remove all dirt and natural oils or wax. Then, while held under tension, they are immersed for a certain length of time in a properly prepared caustic-soda solution. After this treatment the material is thoroughly washed, run through a weak acid bath to neutralize any remaining caustic soda, dried, and pressed. "There is not much work to mercerizing," you say, "so why is it such an expensive process?"

When we think of this treatment as being an addition to the ordinary processes of cloth manufacture, we have one reason for the expense. There are many textile plants in our country whose only business is the mercerizing of cotton

hosiery yarns. One such mill which has recently been built in the South is designed to mercerize 50 tons, or 100,000 pounds, of yarn a week, increasing its capacity as need requires. Such plants must be equipped with costly machinery and must employ a considerable number of highly trained technical men. The caustic soda is an expensive item, 25 tons being required for 100,000 pounds of yarn (the weekly output of the above-mentioned mill), costing, early in 1921, about $2000. Fortunately about four fifths of the soda is recovered, as the cost of the process would be prohibitive if this chemical were a total loss after being used once.

Results of mercerization. 1. *Close imitations of silk and linen.* We find many degrees of luster among mercerized materials, the degree of luster depending upon the amount of this treatment they have received. Some are highly mercerized and have a brilliant luster. Highly mercerized cotton damask is used by some of the first-class hotels in the country for their table linen, and so closely does it resemble linen damask that only a very close examination reveals the difference. Certain brands of knitted goods, piece goods, and embroidery yarns can hardly be told from silk, they are so lustrous. High-grade cotton poplin is a good illustration of the effect of this process on dress goods. Other materials have only a slight treatment, which makes them stronger and more beautiful than they would be otherwise, but does not make them likely to be confused with silk or linen.

2. *Beautiful and inexpensive mixtures.* The combination of mercerized cotton yarns with yarns of other fibers, either to beautify the material or to reduce its price, is one of the greatest achievements of mercerization. Mercerized cotton yarns are combined with silk yarns in silk mixtures for dress goods, linings, draperies, and upholstery materials. They are used in both silk and wool knitted goods. They are combined with linen yarns in personal and household linens.

They are sometimes used in woolens and worsted mixtures. Mercerized yarns are often combined with untreated cotton yarns to produce the lustrous stripes and figures in many kinds of cotton wash goods. Sometimes only one set of yarns in cotton materials is mercerized. Two-toned effects are often heightened in this way, as illustrated by Stafford cloth. In fact, one is constantly amazed to discover how frequently the beautiful effect of all kinds of fabrics is produced by mercerized cotton yarns. During the World War the mercerizing of cotton, like so many other nonessential industries, was much decreased, and almost no mercerized materials could be found in our stores. Mercerized yarn for hosiery increased from 55 cents per pound in 1914 to $3.25 in 1919. Mercerized materials at a reasonable price have returned, however, and their usefulness will increase as people grow more intelligent about them and more appreciative of their value.

3. *Crinkled and crêped effects.* How do you think the puckered spots in plissé, and the queerly striped, crinkled effect of serpentine crêpe, are formed? At first glance we are sure this appearance must be produced by different sizes of yarn or by different kinds of weave. Are you not surprised, therefore, to discover that these effects are produced by this same chemical treatment of mercerization? Caustic soda, as we have seen, swells, or plumps, the cotton fiber, thereby increasing its diameter but decreasing its length. This causes permanent shrinkage of the goods. To produce the combination of plain and puckered effects in the same piece of material, certain parts of it are treated with caustic soda, thereby causing shrinkage, while the rest of it is untreated and remains its natural size. Consequently the parts not shrunken pucker, or ruffle, to conform to the size of the shrunken parts. How can this spotty mercerization be accomplished? Our engraved printing rollers are again brought into use, printing a resistant upon cloth that is to be

mercerized, as they do upon cloth that is to be dyed. When this resist-printed material is immersed in the caustic-soda solution, the places that have been treated remain their original size, while the exposed parts of the cloth shrink and thicken in the mercerizing bath. Is it not interesting to learn that such a peculiar appearance in fabrics can be brought about by such a simple process?

There are almost innumerable kinds of treatment given to cloth in the final finishing operations, depending upon the nature of the goods and the purpose for which they are intended. The treatment given to cotton and linen materials would be highly unsuitable for wool or silk fabrics, because of the peculiar character of each class of fibers; while the finishing of woolens and worsteds, crash and damask, velvets and satins, khaki and organdy, are widely different, even though the raw material is the same in each pair of cloths mentioned.

The finishing of worsteds. The finishing of woolens and worsteds emphasizes the differences begun by the spinning process. An English writer[1] states that there are from twenty to twenty-five different operations in the finishing of some kinds of cloth after weaving, and he proceeds to enumerate more than twenty to which high-grade wool materials are subjected. They are as follows:

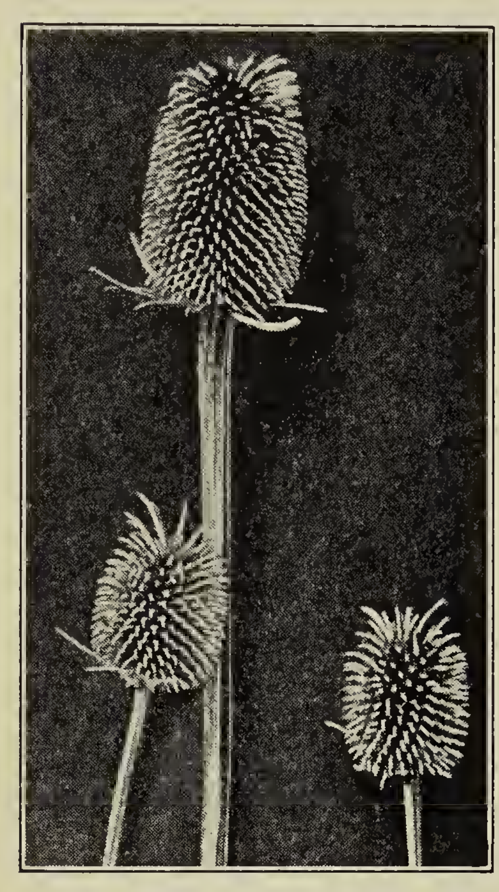
perching
mending
soaping
milling (which includes pounding and hammering)
scouring
hydro-extracting
crabbing
tentering
brush-dewing
double-brushing
steaming
raising
cutting
double-brushing
second mending
dry-steaming
blowing and exhausting
cutting and measuring
pressing
steaming-off
cold-pressing

[1] Frank Ormerod, Wool, p. 99.

The finishing of woolens. Woolens, as you remember, are woven from soft, rather loosely twisted yarns made from the shorter wool fibers. From the nature of the fiber and the character of the yarn it is possible to shrink and felt a woolen cloth into a much thicker, firmer material than when first woven, and yet it will remain soft and springy to the touch and fuzzy in appearance. So woolens are scoured, soaped, boiled, and beaten, to shrink, full, felt, or mill them. This fulling operation lasts for hours, certain parts of it being repeated many times. During this process the cloth is shrunk to specified size. Nearly all woolens are shrunk from 15 to 20 per cent, and for such heavily fulled cloths as heavy broadcloth, mackinaw, and melton they are sometimes reduced by this process to half their original size. Many woolens are napped to increase the fuzzy appearance, the napping of broadcloth being one of the important operations in the finishing of this material.

Napping, or teazeling. Napping consists in uniformly pulling out the ends of the fibers over the surface of the cloth, and is usually done by passing it between rollers covered with tiny wire teeth. With fine broadcloths, however, another kind of napping instrument has long been used and is still the favorite tool for pulling the ends of the fibers to the surface. Did a burdock burr ever get caught on your clothing? Did you notice, when you pulled it off, how tenaciously it clung and how tough its little hooked points were, springing back but not breaking as you pulled the burr away from the cloth? There is a longer burr called the teazel, which grows in New York State and in many other localities in our country, that has the same characteristics as the burdock burr, and these teazels have for a long time been used for napping fine, light-weight woolens. In fact, the process is often called teazeling. Napped knitted goods is much used at times for caps, scarfs, and trimmings of sweaters.

The nap on these knitted goods is usually raised by rollers with stiff brushes, and such goods are spoken of as brushed scarfs, etc. The napping of any material is not usually completed in one operation, the finest goods being submitted many times to gentle applications of this treatment. Some of our high-class wool knitted goods, with long, heavy nap, are brushed as many as ten or twelve times.



TEAZELS

Napping somewhat weakens materials, but it also increases their warmth. Fleece-lined hosiery and knitted underwear are napped on the inside for this reason. Both cotton and woolen blankets are heavily napped on both sides, thereby greatly increasing their warmth. Eiderdown and canton flannel have a heavy nap on one side. Outing flannel is well napped on both sides, and flannelette is lightly napped on only one side. After napping, the surface of the goods is usually sheared or clipped so that the ends of the fibers are of uniform length. On materials requiring a velvety finish the nap is raised by rollers covered with emery cloth, and such goods are said to be emerized. The nap on chamoisette gloves and high-grade duvetyn is raised in this way.

The filling of cloth. With many cloths it is desirable that the spaces between the yarns should be filled, making the material heavier and making it seem more closely woven than when taken from the loom. The process of filling these interstices is performed in many different ways.

1. *Flocks.* Sometimes very short fibers, called flocks, that have been clipped from the napped woolens are blown or beaten and felted into woolens during the milling process, thus adding weight to the material. Noticeable rolls of dust that are frequently found along the seams or inside the hems of woolen garments may be these short fibers that have come out with wear.

2. *Mineral solutions.* Silks are treated to a solution of mineral salts, which they readily absorb, thus greatly increasing their weight and body. This is called loading, weighting, or dynamiting and is further described in the chapter on silk. The reason why some apparently thick, heavy taffetas split or break so quickly is because of an excess of this loading material.

3. *Chalk and clay.* Cotton fabrics are often given body with chalk, china clay, talc, or an excess of starch. For some purposes, as for linings of trunks, bags, and boxes, and for sacks to hold materials which are to be kept dry, these filled cloths are desirable. For durability and laundering purposes, however, they are a disappointment. After the filling is washed out the fabric that seemed so firm and close before has become limp and sleazy. If a suspiciously heavy, cheap cotton material is given a vigorous rubbing between the hands, it usually releases the filling in the form of a white powder, leaving the cloth more nearly in its original form. A certain well-known manufacturer of window shades explains very graphically in his advertisement that the fabric in his shade will give satisfactory wear because it is not filled with these foreign substances.

4. *Rice powder.* Cheap pongee is often heavily filled with rice powder. This material may have the appearance of being firm and heavy when in the store, but during the making of a garment much of this white powder falls out, and the cloth becomes loose and sleazy after being washed.

Stiffening and softening of cloth. Most cottons (excepting mercerized materials) and many linens are sized, or starched, some being very heavily stiffened, like organdy, tarlatan, and buckram, and others very lightly, like batiste, nainsook, voile, and unbleached muslin. There are many kinds of these starches, made from corn, wheat, potatoes, rice, casava, sago, and tapioca, each especially prepared, the recipe being kept a secret by the individual finisher. Besides the starches there is a great variety of other materials that go into the dressing and finishing of fabrics. Sugars, gums, glues, sulphates, and phosphates are used, each combination for a particular purpose, as we shall see later. Many materials, particularly silks, need to be softened after the manufacturing process. For softening, oils, glycerin, paraffin, tallow, soaps, and waxes are employed in such ways as to give the right appearance and feel to the material. The effect of the softening process is well illustrated by comparing chiffon taffetas, which receive this treatment, with stiff taffetas of the same quality.

Tentering. The stretching of cloth to width, thereby pulling the filling yarns straight across the goods, is called tentering and is one of the most interesting mill processes to watch. Perhaps you have heard the old-fashioned expression "I feel as if I had been hung *on tenter hooks*," which means "under a nervous strain." When one sees the tentering of cloth in a mill the full significance of the expression comes to him. The tentering machine consists of a horizontal frame about one hundred feet long and three or four feet wide, filled with hot steam pipes, on each side of which is an endless chain set with clips or hooks a few inches apart. These clips automatically open to receive the selvages of the cloth as it enters the frame, and proceed to draw the material slowly over the steam pipes, automatically releasing it at the end of the journey. The ceaseless traveling of the chains is

what pulls the cloth along, but the two chains do not operate in unison. Instead, one chain jerks forward a few inches, carrying the cloth with it, then stops while the chain carrying the other edge of the cloth does the same. By this alternating motion the cloth is yanked first in one direction, then in the other, during the entire length of the machine, and at the end of the hundred-foot journey it is likely to be dry and stretched to its maximum width. Materials that have been tentered usually tear straight across the goods, and the rows of pinholes that we occasionally find in the selvages of fabrics are signs of the tentering process.

Pressing. The pressing of cloth is one of the major operations in the finishing process, for all wrinkles must be removed from smooth-surfaced cloths before they are ready to be sold. But the pressing of cloth is done not only to remove wrinkles but also to give a polish, a pattern, or a leathery feel, as may be desired for the particular kind of material. We know that in home ironing some articles are more satisfactory if they are ironed when very damp, while others need to be only slightly dampened or even dry. Some garments look better if ironed under a wet cloth, while others need to be pressed on the wrong side. Certain materials react best when a very hot iron is used; others require an iron much cooler. A heavy pressure, such as is given to stiff collars by the Chinese and other commercial laundries, produces much more of a gloss than the lighter pressure that can be given at home with an ordinary iron. These principles of the ironing process that are known and practically applied by good housekeepers are all worked out scientifically by the manufacturers in the pressing or ironing of new cloth, each kind being pressed by the method best suited to bring out the desired finish. The pressing in a factory is usually done by running the cloth between rollers, somewhat like the mangles in our steam laundries. Materials may be pressed

much or little; pressed when wet or when dry; with hot rollers or with cold rollers; with plain rollers or with carved rollers; with solid rollers or with rollers made up of a series of hammers which strike the cloth with successive blows. As a result fabrics may have a high polish, like broadcloth, silkaline, and sateen, or they may have little or no polish, like flannel, unbleached muslin, and cheesecloth; they may have a polish on one side, like the various brands of cambric, or on both sides, like percaline. These various pressing operations have different names, as *mangling*, *calendering*, *beetling*, etc. Table linens are pounded by the quick strokes of the individual hammers of which the rollers are made. This is called beetling; it flattens the yarns so that fine, heavy damasks feel almost as compact as leather. Some cloth is subjected to rollers etched in very fine lines, and a high polish called Schreinerizing is produced; other materials are folded and pressed under very heavy, deeply carved rollers which give a watered, or moiré, appearance; while still others are pressed by rollers containing carved designs or patterns, producing an embossed effect on the cloth.

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THE MILES OF CLOTH AS IT COMES FROM THE DRYING AND PRESSING MACHINES

Special finishes. Cloths to be used for particular purposes are given special finishes. To make them resist water, materials are treated in a variety of ways. Some classes of goods are made impervious to water in any form; they are strictly waterproof. To be made waterproof, materials are usually coated with some kind of oil or paraffin, as oiled silk for raincoats and toilet purposes and paraffined duck for loggers' "tin pants," or with rubber for slickers, rubber footwear, and stork sheeting.

Other cloths are subjected to a chemical treatment which prevents their becoming damp in the presence of moisture. These cloths are made "moisture repellent" or "moisture resistant." Our familiar cravenetted materials have received a treatment of this kind. Army overcoats and blankets are treated so as not to become heavy with moisture in damp weather, as the weight of water-soaked garments would add greatly to the fatigue of the soldiers on their long marches in the snow and rain.

Cloths are often treated with substances that cause a glaze on the surface, like the ciré ribbons that have been so popular at times. Real English chintz is finished with a high glaze. Cloths may be gummed, like our gummed tape and court plaster; they may be painted, like our oilcloths and linoleums; they may be fireproofed, like some of our outing flannels that otherwise are so inflammable; or they may be made unshrinkable, like nonshrinking flannels and knitted goods.

Purpose of the finishing processes. There seems to be an infinite number of ways in which fabrics are treated after the weaving operation. It is said that there are many more kinds of finishes than there are kinds of cloth. The two main purposes of all these final treatments, however, remain the same. Finishing is given to cloth either to beautify its appearance or to make it better suited to the purpose for which it was intended.

QUESTIONS AND ASSIGNMENTS

1. Get samples of three kinds of cambric and compare as to:

    fineness
    weight
    finish

2. Do the same with sheeting or pillowcase tubing.

3. Bring a sample of the best mercerized damask that you can find. Compare it in every way with linen damask *of the same price.*

4. How should table linen be ironed to produce the best results? How should colored cotton garments be ironed? How should you press a wool skirt? a Georgette blouse?

5. Name and bring three samples of cloths that imitate silk; linen.

6. What five materials are usually mercerized? How do they range in price? Compare with unmercerized materials of approximately the same quality.

7. Name a popular trade-marked mercerized pajama cloth; one used for lingerie.

8. In what department of the store do we find much mercerized material not in the form of cloth?

9. Get samples of nainsook, batiste, long cloth, and cambric of about the same grade and compare their finish.

10. Compare the appearance, price, and wearing qualities of a high-grade mercerized knitted undergarment with one of silk.

11. Name and bring samples of materials only partly mercerized. Examine these materials.

12. Give three names for inspection of cloth; three for shrinking.

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See page 369.

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CHAPTER XI

RAW MATERIALS WHICH ARE MADE INTO CLOTH: THE FOUR PRINCIPAL FIBERS

Illustrations in cloth of types of raw material. The least apparent but most important fundamental reason for differences among cloths can easily be discovered in these four simple articles: (1) a cotton handkerchief, (2) a linen handkerchief, (3) a silk handkerchief, and (4) a piece of fine white flannel of about the same size. (Number 4 may be represented by a garment, as a baby's petticoat, or it may be a sample of flannel much smaller than the handkerchiefs. It is possible to use any piece of white wool material for this purpose, but flannel allows the best comparisons.)

These articles should all be white and should be of plain weave, and the yarns of all should be of about the same degree of fineness. It is better if all of them have been laundered, and it is quite essential that Numbers 1 and 2 shall have been washed at least once since they came from the store.

As we handle and examine these different pieces of cloth we are conscious that, while they are all alike in weave, all made from fine yarns, and all uncolored, there are still many differences among them. We may confuse Numbers 1 and 2, but we could never confuse any two of the others.

Physical characteristics of the four fabrics. By studying these fabrics individually we see that Number 1 is a smooth, firm cloth; the weave is simple and the yarns are regular in

size throughout their length. This handkerchief is soft and rather limp, and has little luster. It wrinkles as we crush it in our hand. If we rub it briskly and then look across it, we may see a little fuzz like the tiny curled ends of fibers sticking out over its surface. This cloth has doubtless been singed, and it may have been mercerized, but friction still causes the ends of fibers to escape from the yarns. Drop a tiny bit of water on the handkerchief and watch it spread over the cloth.

Number 2 is also a smooth, firm cloth with plain weave. When we look closely at the yarns, however, we see many irregularities. There are places where a yarn gradually grows larger and then slowly tapers off to its original size, while again the swelling may be sudden, making almost a little knob or bunch in the cloth. This handkerchief is so smooth as to feel slippery, and it is crisp, almost stiff, in body. Crushing it in our hand wrinkles it badly, and rubbing this fabric causes no fuzz to be seen on its surface. This material feels cool to the touch and has more luster than Number 1. If our eyes are quick enough to detect the difference, we shall see that the water we drop on this handkerchief spreads more quickly than on the first one. An old method of discriminating between the two materials of which these handkerchiefs are made was to wet the finger in the mouth and thrust it under the cloth. If the moisture came through instantly, it showed the material to be linen. Nowadays this test is considered neither hygienic nor accurate.

As we pick up the silk handkerchief it gives us a feeling of pleasure. We like to touch it, to handle it, to put it against our cheek. Why does it so appeal to us? When we examine the fabric we see that, like the other two handkerchiefs, it is a firm cloth of simple weave, and that, as in the cloth in Number 1, the yarns are uniform in size throughout their length. But the softness and the smoothness of this handker-

chief, and the shimmer! Could anything in cloth ever surpass in these characteristics this material? This cloth is neither limp nor crisp, but flexible enough to yield to any pressure and still retain a certain independent character of its own. If we crush this handkerchief, the wrinkles are much less conspicuous than in either of the others, and friction does not cause fuzzy ends to appear upon its surface. A drop of water spreads very quickly on this handkerchief, but dries almost instantly.

Number 4, the wool article, whether it is a sample of flannel or a baby's petticoat, is very different from any of the others. It too is a firm cloth of plain weave, and the yarns appear uniform throughout their length, though they can be seen less clearly than those in any of the handkerchiefs. Flannel seems warm to the touch, but when rubbed against the cheek it feels neither soft, slippery, nor smooth. Instead it seems almost scratchy, and we are glad we do not have to use flannel for a handkerchief. This material is elastic, and when we crush it in our hand it springs back to its original form so quickly that no wrinkles remain. Friction from rubbing is not necessary to produce a fuzz on this cloth; its surface on both sides is well covered with the curly ends that cause the nap. There is little luster to flannel, and water dropped on it is absorbed very slowly. When once wet, however, this material will remain damp a long time.

This very superficial examination of these articles shows us wide differences in the character of the four fabrics, the dissimilarity in every instance being caused by the individual characteristics of the particular kind of raw material used. Cotton, linen (or flax), silk, and wool, of which these four articles are made, are the principal textile raw materials. There are several other kinds of fiber which are less extensively used than these four, and they are briefly described in a later chapter.

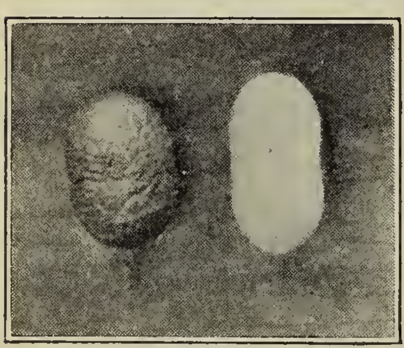
Sources of the raw materials. 1. *Geographical.* Textile raw materials are produced all over the world. Cotton is grown in the hot climates (in India and China, along the Nile Valley, in South Africa, and in South America), the largest amount being produced in the southern part of our own country. Flax requires a damper, cooler climate, such as is found in the British Isles, Russia, Belgium, Canada, and some of our Northern and Northwestern states.

A COTTON BOLL

The wonderful worms that spin the silk flourish wherever the mulberry tree, which is their source of food, will grow. We find silkworms in China, Japan, India, Italy, France, Spain, California, and some of the Southern states. Sheep, from which we obtain wool, can live wherever there are good grazing lands. This includes a wide range of temperature, and sheep are raised in Canada, the United States, South Africa, Australia, and South America.

2. *Physical.* We will now study the raw materials of which these fabrics are made. The fluffy, white lint which is used for cotton materials is firmly attached to seeds within the boll, or fruit, of the cotton plant. This soft down is grown by the plant to assist the wind in the distribution of its seeds.

Flax, from which linen cloth is made, is found inside the bark, or woody covering, of the stem of the flax plant. It is called a bast fiber, and since it is a part of the structure of the plant, the procuring of this fiber necessitates its destruction. The silk that we use is the laboriously built house, or cocoon, which the silkworm makes, and in which it hides away while changing from an ugly worm to a beautiful moth. The silk fiber is the substance the worm ejects to make his cocoon. He employs the same principle as a spider spinning his web, though the silkworm chooses quite a different style of architecture.



SILK COCOONS

Wool is grown by sheep for their own warm protective covering. To be "dressed in sheep's clothing" bears no stigma when the expression is interpreted literally, for who is there among us who does not depend upon the docile sheep for his warmest garments? Instead of allowing the sheep to shed his winter coat by degrees, as other fur-bearing and hair-bearing animals do, man suddenly snatches the sheep's clothing from him, as it were, by shearing his entire body in the spring. Whereupon the sheep immediately begins to grow another coat, which may be disposed of in the same way.

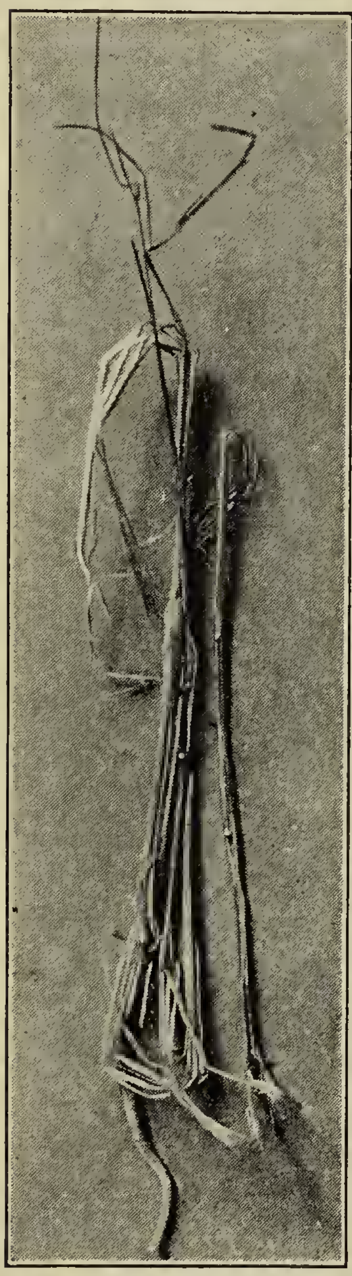
Therefore, of our four main textile raw materials, two are produced by plants and two by animals. In their natural state the two plant fibers have somewhat the same characteristics, as in cotton and linen cloth. In the same way, the two animal fibers show similar qualities, as do silk and wool fabrics. We should never confuse cotton and flax or wool and silk in their raw state, and with closer observation and greater knowledge we shall never confuse the cloths into which they are made.

Examination of the fibers. Let us pull out from each of these kinds of raw material the very tiniest piece we can withdraw. This is called a fiber, a term we have already used. By closely inspecting the cotton fiber which we have drawn from the boll, we find that it is a short filament about an inch long; that it is finer than the finest thread or hair;

BEFORE AND AFTER SHEARING

and that it is clean, white, and curly and breaks easily. Flax fiber, on the other hand, is long, perhaps twelve inches or more in length; it is fine, and yet we can continue to split it even finer; it is straight, brown, and tough. The wool fiber varies greatly in length (from one to eight inches or more) and has a curly, crimpy appearance. It is yellowish and greasy and by stretching it we see that it is elastic. The silk fiber that we pull from the cocoon is very long, fine, yellow, and also elastic.

These are only the obvious physical characteristics of the fibers, but we shall see that to a great extent they govern the character of the cloth made. The short fibers of the cotton make a cloth with a fuzzy surface which must be singed for a smooth finish. The fineness and curliness of the fibers allow a strong, even yarn to be spun, —the kind shown in handkerchief Number 1.



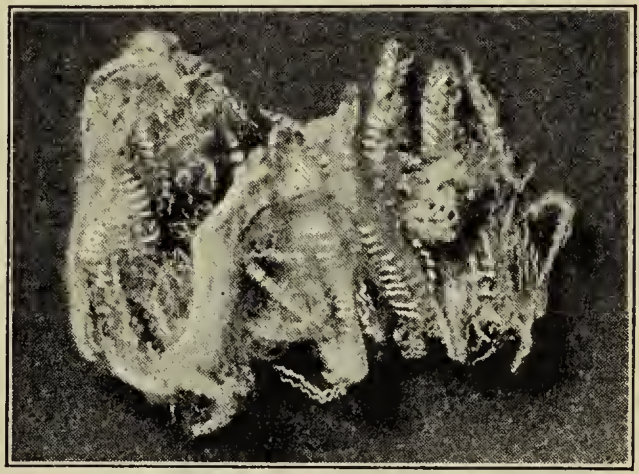
FLAX

The fibers can be seen in the broken part of the stem

The long, straight flax fibers do not surprise us with their stiffness and toughness. To be a part of the structure of the plant stem they must have strength and uprightness. Hence the linen cloth made from the flax fiber must be crisp and strong. Linens long outwear cottons when used for the same purposes, and the crispness and smoothness never disappear. In the spinning process it is quite impossible to make as uniform a yarn with the straight flax as with the curly cotton fibers, so uneven yarns are a characteristic of linens. Because the fibers of the flax are long and smooth they reflect the light, and the luster of linen endures as long as the cloth lasts.

"As soft as silk" is a proverbial expression, and one reason for this softness is the length of the fiber. As we pulled it from the cocoon the tiny silk filament may have broken when it was only two or three inches long. That is because we are not skillful in handling it, for it is possible to

unwind the entire peanut-shaped home of the silkworm into one unbroken strand. The worm makes this shell, not to produce silk fiber for us, but as a place of concealment and protection for himself, and he makes it perfect in structure. He spins without ceasing from the time he starts until the cocoon is finished, the entire length of the filament often measuring from 3000 to 4000 yards. Silk is the only natural fiber that man does not have to spin. He has only to double and twist these long strands that the worm has spun for him. The worm deposits a gum on the outside of the fiber, which hardens in the air but is relatively easy to remove, exposing the clean fiber. When these long, smooth, flexible fibers are made into yarn and cloth, is it any wonder that silk materials possess the delightful qualities that give us the feeling of pleasure as we pick up the silk handkerchief? Silk is the strongest textile fiber for its size in the world, being, it is said, nearly as strong as a steel wire of the same diameter. Good silk materials will long outwear those of the same weight made from any of the other fibers.



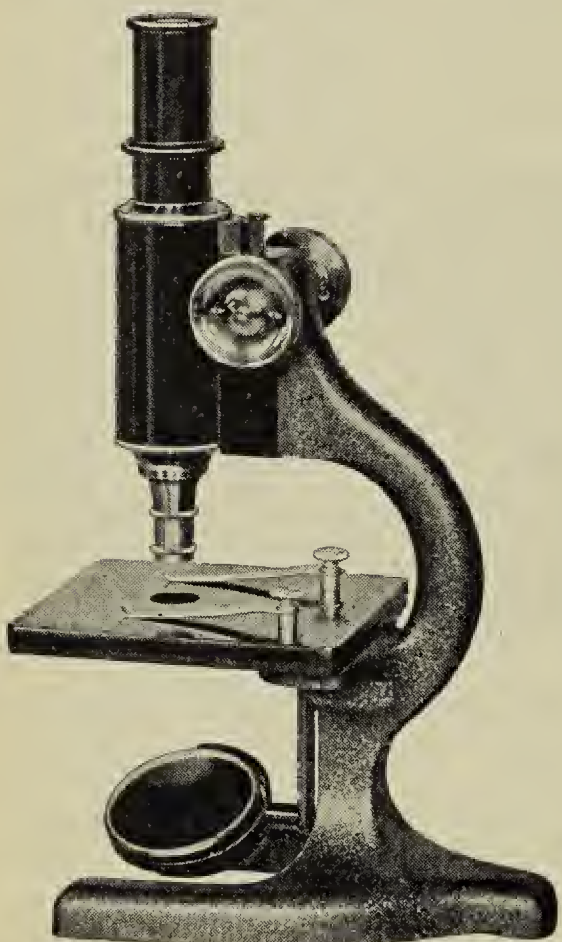
WOOL

Note the crimps

We have now the curly, crimpy wool fiber, in which the curl persists like the kink in Topsy's hair. Are you surprised that, with all those curly ends escaping, cloth made from this fiber should be fuzzy and scratchy? Like cotton, this curl or kink assists in spinning, and wool makes strong, even yarns. Stretch the wool fiber and see how quickly it springs back to its original length. The wool sample that we ex-

amined was elastic and would not wrinkle. We can now see why cloths of wool, whether woven or knitted, are desirable for our suits, coats, and dresses that are so often likely to be wrinkled.

It is evident, therefore, that the characteristics which can be discovered with the naked eye in these tiny fibers appear in the cloth they make. Fibers have other important properties, however, that can be discovered only by the employment of special textile-testing apparatus or by the use of chemicals.

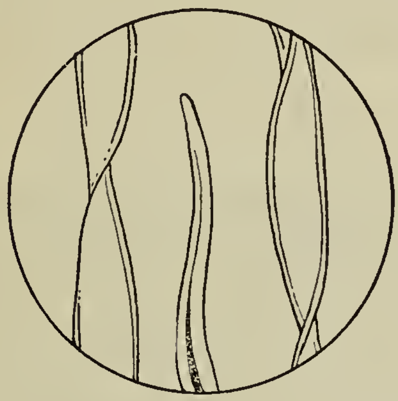


A MICROSCOPE

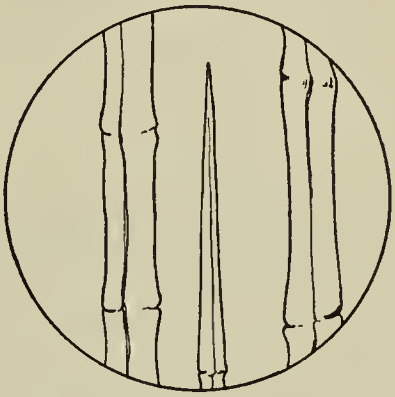
Courtesy of Spencer Lens Company

1. *Microscopic structure.* The microscope shows the four fibers to be very different in structure. The cotton fiber that appears to be a curly cylinder is really flattened along its entire middle course, as was described in Chapter X, and has from 150 to 300 twists per inch. This peculiar structure helps to hold cotton fibers together while they are being spun, even though each individual filament in the yarn may be less than an inch long. The flax fiber shows almost a smooth structure under the microscope. As in bamboo, there are little joints, or nodes, at intervals along its length, slightly varying its size, but there are no twists. This smooth fiber makes linens slippery, so that they soil much less quickly than cotton. Consequently linen fabrics are more

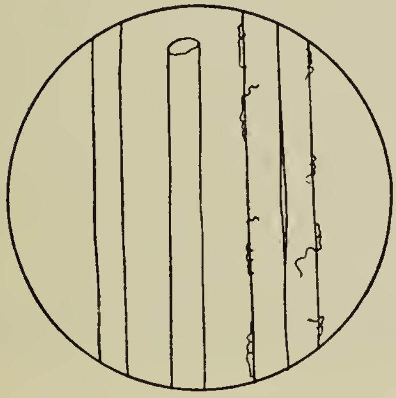
sanitary than cotton. The microscope proves silk to be a structureless fiber, uniform in size, like a glass rod, and composed of two filaments. This lack of structure of the fiber gives to silk fabrics their wonderful smoothness and



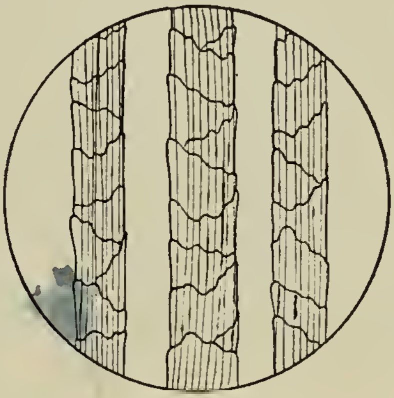
COTTON FIBERS (HIGHLY MAGNIFIED)



FLAX FIBERS (HIGHLY MAGNIFIED)



SILK FIBERS (HIGHLY MAGNIFIED)

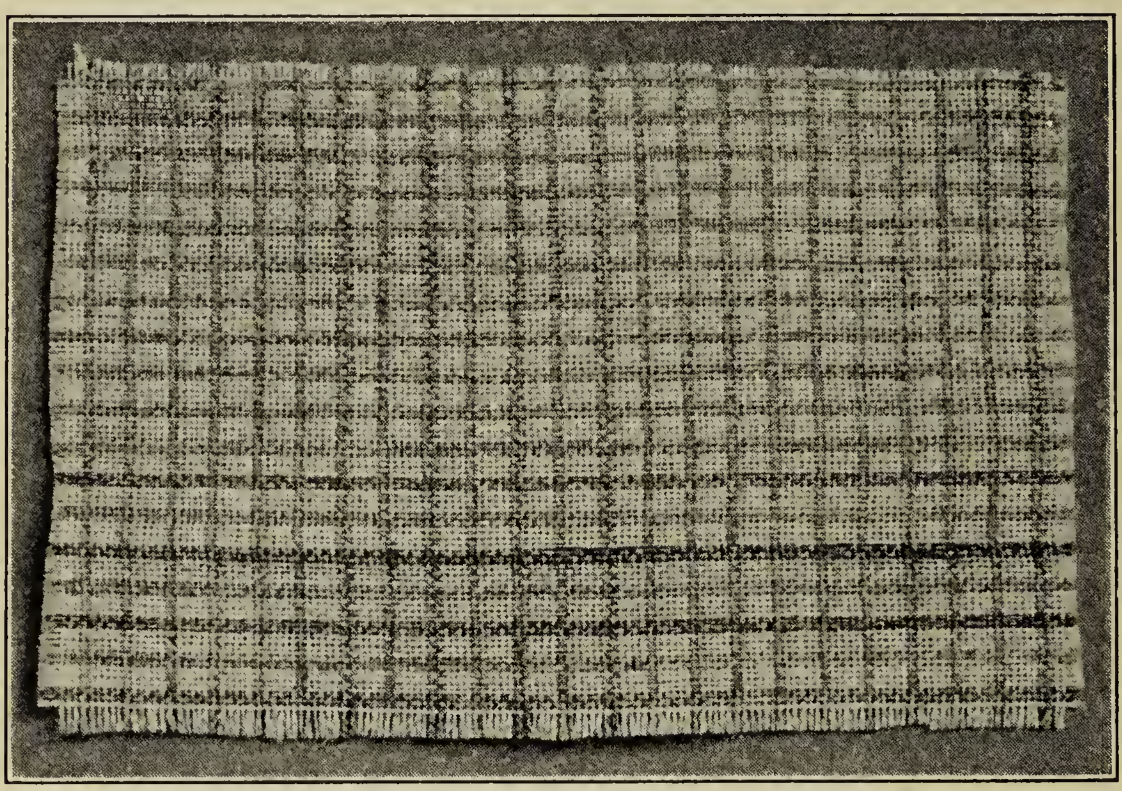


WOOL FIBERS (HIGHLY MAGNIFIED)

luster. Silk sheds dust and is the cleanest fabric known. The dirt-resisting property of silk materials makes them particularly desirable for waists, petticoats, underwear, and traveling suits.

Wool fiber is the most interesting of all under the microscope. It is not twisted like the cotton fiber, nor is it smooth like the flax and silk. Instead, its entire surface is made up of tiny overlapping scales (from 1000 to 3000 per inch) like

the scales on a fish or a pine cone. When heat and moisture are applied to a wool fiber its scales open out like those on a dry pine cone, and when cold is applied they quickly and tightly close. When many of the wool fibers lie close together, as in yarn and cloth, the scales of each one tend to catch into the scales of the others touching it, and the whole mass of fibers may become interlocked in that way. This

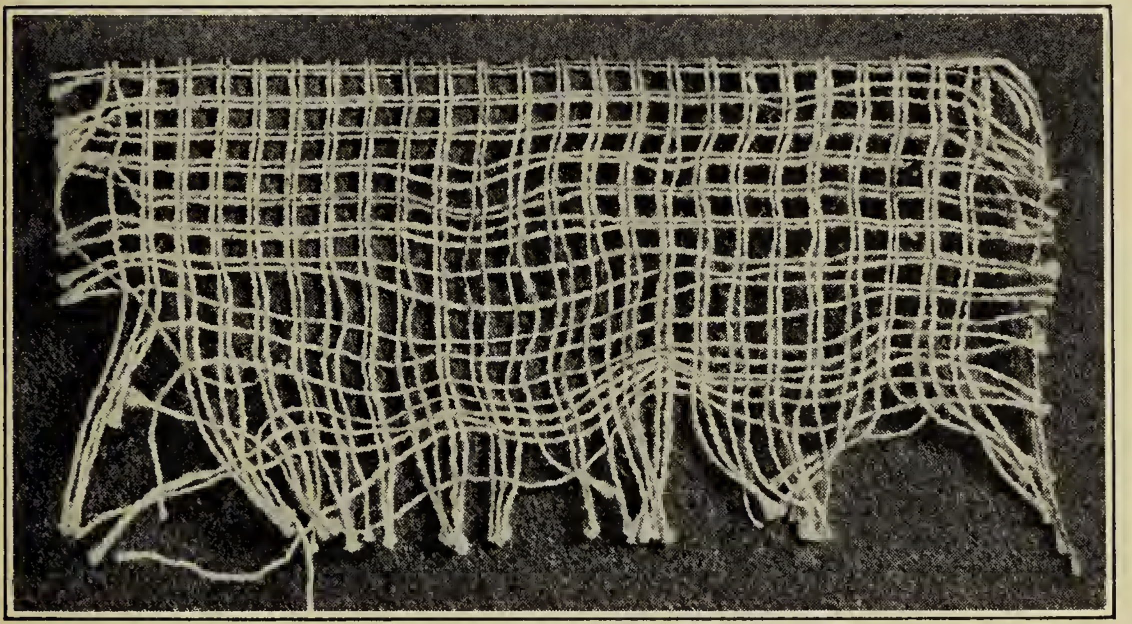


A COTTON AND WOOL MIXTURE

is what happens when your wool sweater or stockings shrink in washing. The manufacturer makes use of this sensitive characteristic of the wool scales, and frequently lets them do part of his work for him. The poorer qualities of felt are made without spinning or weaving, the wool fibers being shrunk and beaten together. In heavily fulled cloths the material is often woven twice the size the cloth is to be when finished, and is then shrunk to size. Can you see why wool materials are more desirable for outer garments than for

underwear? There is a way of treating wool chemically so that the fibers lose this power to open and close their scales; but unless wool goods are guaranteed unshrinkable, this treatment has not been given.

2. *Reaction to chemicals.* Other properties of cloth can be discovered by observing the action of chemicals on the fibers. Two classes of chemicals in their various forms are very common in our everyday life. They are the acids and



THE SAME CLOTH WITH THE WOOL DESTROYED BY AN ALKALI

the alkalis. Sour milk, vinegar, lemon, and other fruit juices are common household acids, while hydrochloric (common name, muriatic), nitric, and sulphuric acids are laboratory chemicals. Borax, ammonia, washing powder, lye, and caustic soda are examples of the alkalis. All soaps contain alkali, but a good soap has the alkali held in combination with other substances, so that the soap is said to be neutral, containing no free alkali. Alkalis injure all animal fibers somewhat, and, if strong, will entirely destroy them. But alkalis have little effect upon vegetable fibers. Therefore, in washing woolens and silks the kind of soap should be carefully

chosen. Now can you see a reason why cotton and linen rather than wool are used for articles that require frequent laundering?

Acids tend to injure vegetable fibers more than animal fibers, though strong acids are injurious to both. A mild acid, like sour milk, is practically harmless, but if lemon juice and salt, or oxalic acid, are used to remove stains from our table linen or our cotton clothing, the acid should be thoroughly washed out if we do not want a weak spot or a hole to appear in place of the stain. All the stronger chemicals named should be used with the utmost care. Not only should the fabric be thoroughly washed after their use, but their action should be neutralized by the use of an alkali (ammonia or borax) in the water.

This knowledge of the microscopic structure of fibers and of their reaction to chemicals helps us to know how to treat our clothing and our household linens so that their life and beauty will endure. It shows us that plenty of soap, if thoroughly rinsed out afterward, can be used in washing cottons and linens without injury to the cloth. It shows us that the combination of moisture and change of temperature does not affect vegetable fibers. White cottons and linens can be boiled or hung out and frozen and will not be impaired. It teaches us better than to boil a flannel shirt, as ignorant laundresses have been known to do, or to try to make baby's damp flannels smooth with a very hot iron,—a frequent method of inexperienced mothers. It teaches us that there are no ridges, twists, or scales for the dirt to cling to on the smooth silk fiber, so dirt is easily removed. No boiling is needed, and gentle treatment is best in all the steps of laundering silk.

The knowledge of chemical reactions of fibers is further useful in testing cloths to find out whether they contain any suspicious or unexpected fibers. The tests given at the end

of the chapter can be made with comparative accuracy in the home. When made by exact methods in the laboratory they give the final verification of the salesman's remark when he says, "This coat is absolutely all wool" or "There is not a thread of cotton in this plaid suiting."

General uses of the four classes of cloth. What, then, are some of the general uses to which these different cloths are adapted? If we wish to use the material for practical purposes where constant wear demands frequent laundering, as for underwear, children's play clothes, men's shirts, and women's house dresses, we buy cotton. Cotton is the cheapest fiber and the one best adapted to utilitarian purposes.

If we desire cloth that will make cool and crisp-looking garments, particularly after every fresh laundering, or if we wish it for absorbent purposes, as towels and handkerchiefs, or if it is to be used for articles where smoothness, cleanliness, and luster are prime requisites as long as the article lasts, linen is the material to use. Linen sheets are a perfect joy in a warm climate, and no fabric can replace linen for table uses. Linen is not cheap in price, though its long life causes it to be less expensive than its cost at first indicates. It is the cloth that satisfies our æsthetic tastes, and every woman loves to possess some pure linens.

For articles of beauty and elegance we buy silk. It is the first material we think of in connection with elaborate gowns, beautiful ribbons, dainty underwear, and rich-looking draperies. Silk can be made into thick, heavy cloths or into those light as "woven wind." It can be given a soft, dull finish, or the most brilliant luster can be brought out on its surface. It is found in every weave and in an unlimited variety of colors. In its somber hues it makes attractive suits and dresses for business. Silk is the most expensive fiber there is, but its wide variety of uses allows almost everyone to enjoy it in some form.

For warmth and protection from the elements we turn to wool. The suits, skirts, or coats that we are wearing at this moment are probably made of wool. Perhaps we have wool in our underwear or stockings. If we are where the weather is cold or damp, we surely sleep under woolen blankets, have a woolen rug for our automobile, and perhaps wear woolen gloves or mittens. Wherever the climate is rigorous there would be much suffering without wool clothing. Wool is not a cheap fiber, though its cost is influenced by various factors. It usually ranks next to silk in price.

Each of these four classes of cloth, therefore, seems peculiarly suited to fill a particular need in our daily lives,—a need for which no other cloth is equally well adapted. Nearly everyone knows that certain kinds of cloth are generally used for certain purposes, but comparatively few people know that the establishment of such universal customs has been brought about entirely by the nature of the tiny fibers of which the cloth is made.

DIRECTIONS FOR LAUNDERING WOOL MATERIALS

All the waters used in laundering the materials should be lukewarm. A foamy suds should be made from a neutral soap or soap solution. The article should be doused up and down and squeezed instead of rubbed in the suds. There should be several rinsing waters, the first of which should be a very weak suds. The water should be *squeezed*, not *wrung*, out of the article, which should be dried in a temperature about the same as that of the lukewarm water. If ironed, it should be *pressed*, not *rubbed*, on the wrong side with a *warm*, not *hot*, iron.

NOTE. Sweaters or other knitted garments that tend to stretch or shrink should be measured before being washed. They should be spread out to dry on a horizontal surface and pulled to measurement.

REMOVING STAINS AND LAUNDERING

Send for *Farmers' Bulletin No. 861* (September, 1917), United States Department of Agriculture, Washington, D.C., "Removal of Stains from Clothing and Other Textiles"; probable price, 5 cents.

Excellent directions for laundering and taking out stains are given in a booklet, "Approved Methods for Home Laundering," by Mary Beals Vail, published by the Procter and Gamble Co., Cincinnati, Ohio. It is advisable to send for this pamphlet.

For laundering with a washing machine a booklet, "You and your Laundry," by Mrs. Christine Frederick, issued by the Hurley Machine Co., New York, Chicago, and Toronto (Canada), is helpful.

TESTING WOOL MATERIALS

To remove wool from a cotton and wool mixture, dissolve one heaping tablespoonful of household lye in a pint of water. Boil sample five minutes in this solution. This will destroy the wool and leave the cotton.

QUESTIONS AND ASSIGNMENTS

1. Which of the four classes of cloth described in this chapter is never used for umbrellas? handkerchiefs? stockings? table damask? Give the reason in each case.

2. What class of cloth is desirable for dish towels? negligees? hat trimmings? infants' slips? children's rompers? overalls? women's summer traveling suits? Give the reason in each case.

3. Among the different species of cotton the fibers vary from ½ inch to 2½ inches in length. Name three materials in which you would expect the longer fibers to be used; three made of the shorter fibers. Give reasons for your answers.

4. Draw each of the fibers as it appears under the microscope.

5. List the characteristics of the four fibers in the form of the following table:

	Wool	Silk	Cotton	Linen
1. Source				
2. Length				
3. Straightness . .				
4. Structure . . .				
5. Cleanliness . .				
6. Elasticity . . .				
7. Strength . . .				
8. Luster				
9. Cost				
10. Laundering property of cloth .				
11. General use of cloth				

6. What are the advantages of cloths made with fibers that are elastic? the disadvantages?

7. How does a knowledge of chemistry help in the care of clothing?

8. Directions for laundering are sometimes attached to the article. Do you think this a good practice? To whom are such directions a benefit? Do you like to have the salesperson give you directions for setting colors or laundering the article you purchase?

9. Bring samples of two kinds of cloth made from each fiber. Mount and describe, giving class, width, price, weave, character, use, wearing qualities, and any other interesting information you may secure.

10. According to the directions given in this chapter or in any of the named authorities, launder a wool article, remove a stain from a cotton or linen material, and "boil out" a cotton and wool sample.

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See page 369.

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CHAPTER XII

FROM COTTON FIELD TO COTTON FABRIC

Cotton the universal fabric. If there were but one fiber in the world from which cloth could be made, and that fiber were cotton, it would be possible to satisfy all man's textile needs. Cotton is, indeed, the "crop that clothes the world," for it is estimated that from three fourths to nine tenths of the world's raiment supply is made of cotton fabrics. Not only is cotton used for the cloth of which garments are made, but it is also the most important material for the accessories of garment making,—thread, tape, binding, belting, and often the trimming of garments. Any notion or small-wares counter will show the multitude of articles classed under that head which are made entirely or in part of cotton.

Among the fabrics used for other purposes than clothing we are amazed to see the great variety made from this fiber. We may find that much of our table linen is of cotton. Perhaps every one of the different fabrics used about the bed on which we sleep is made partly or wholly of cotton. A part at least of our toilet linen is of cotton (face cloths and bath towels are usually made from this fiber), and much of the kitchen linen (dishcloths, mops, and cleaning cloths) is of the same material. For decorative fabrics, compare the quantity of cotton materials used, such as cretonne, scrim, madras, cotton rep, and tapestry, with the amount of cloth made from any other fiber. By searching into more obscure places we find cotton linings in boots, shoes, rubbers, hats, rubber garments, and traveling bags, cases, and trunks.

Cotton bags hold our salt, sugar, and flour; and cotton lacings, cords, and different kinds of string are required for wrapping and tying many of the articles used in the household.

Until the World War came no one realized how much heavy cotton cloth, such as khaki, canvas, and duck, was used for tents, beds, sails, hammocks, and awnings, nor how dependent the world is upon cotton for medical and hospital supplies. Perhaps some of us have heard stories of how during our Civil War the women scraped linen for lint to use on wounds, and tore up and made into bandages quantities of their household linen. Not so during the World War. Tons of absorbent cotton were used, and millions of yards of cotton cloth were woven especially for dressings, bandages, and other hospital supplies. It was with the enthusiasm created by appreciation of its many uses that a professor of agriculture in the South said of cotton, nearly a quarter of a century ago:

> You get up in the morning from a bed clothed in cotton. You step out on a cotton rug. You let in the light by raising a cotton window shade. You wash with soap made partly with cottonseed-oil products. You dry your face on a cotton towel. You array yourself chiefly in cotton clothing. The "silk" in which your wife dresses is probably mercerized cotton. . . . The tobacco you smoke not unlikely grew under a cotton cover and is put up in a cotton bag. Your morning daily may be printed on cotton-waste paper, and even in that skirmish it tells about, the contending forces were clothed in khaki duck, slept under cotton tents, cotton was an essential in the high explosives that were used, and when at last the war had done its worst, surgery itself called cotton into requisition to aid the injured and dying.[1]

During the last few years a new use for cotton fabric has sprung up, of which the worthy professor knew nothing and which he could hardly have anticipated. It is the use of

[1] The Introduction to "Cotton," by C. W. Burkett and C. H. Poe.

cotton for automobile purposes. The statement is made that more than 2,000,000 of the 35,000,000 spindles in the United States are now required to manufacture cotton fabrics for automobile tires and upholstery. It was principally to produce a sufficient amount of the right kind of fiber for pneumatic tires that vast new cotton areas in the United States were opened up in the last few years. Is it any wonder that this fiber is given the exalted title of *King Cotton*?

Reasons for popularity. 1. *Low price.* Why has King Cotton gained such supremacy over the other textile fibers? Perhaps the main cause of the great popularity of cotton goods is their low price. Cotton fiber is the fruit of a plant, and there is always less hazard in developing a vegetable than an animal product. Plants get their nourishment directly from the ground, requiring only one cycle of life for their fruition. The food upon which animals live must first be produced from the ground, thereby requiring two cycles of life for the maturity of animal products. The element of chance, therefore, is much less in producing a pound of cotton than in producing a pound of wool.

2. *A home product.* Another reason why cotton is popular with the people in this country is because so large a part of the world's supply of this fiber is grown here in the United States. Texas alone produced more than 4,000,000 bales of cotton in 1920, the entire crop in the United States for that year exceeding 13,000,000 bales. When we consider that there are 500 pounds in each bale, we begin to realize what an enormous item cotton is among our American products.

Although the United States produces from 60 to 65 per cent of the entire crop of the world, cotton is also grown in South America, Asia, and Africa. India is probably the home of cotton, and it was made into cloth in that country long before the Christian Era. Cotton needs a long, hot summer for the maturing of its fibers, and the great Cotton

Belt of the world is that section between 36° north and south of the equator. A study of the extensive cotton-growing areas will show how readily this plant grows in warm climates.

3. *Adaptability of cotton fiber.* Cotton is enduring. It does not deteriorate with age. After being kept twenty years in a warehouse cotton fiber has been found uninjured. Cotton spins and weaves easily, the natural twist in the fiber allowing strong yarns to be made in a multitude of sizes. The range of cloth made from cotton embraces every known weave and every type of knitting. Almost every weight of fabric made is found in cotton, from the filmiest lace and sheerest Swiss and organdy to the heaviest duck and canvas. It is indeed the "fabric of civilization," and can be adapted to every cloth need of mankind.

Common varieties of cotton. The story of cotton in the United States is interesting. The cotton plant was found growing in the West Indies by Columbus. Other early explorers found it in Mexico and South America. Later, cotton was planted in our Southern states, where it grew easily and prolifically. The botanical name for the cotton plant is gossypium, and it belongs to the mallow family. There are many different varieties of this plant, some of which are perennials, but in the United States cotton is an annual. The most important kinds of cotton used in our materials are Sea Island, Egyptian, upland, and Peruvian.

1. *Sea Island.* The cotton par excellence is Sea Island, which was probably imported from Egypt. It is raised on the islands off the coast of South Carolina, Georgia, and Florida, and its white, silky fiber ranges from $1\frac{3}{4}$ to $2\frac{1}{2}$ or 3 inches in length. Sea Island cotton is the highest type of cotton in the world and is used in materials where strength is required, as in sewing cotton, automobile tires, and United States mail bags, or where beauty is desired, as in laces and fine yard goods like batiste, nainsook, and cambric. There is

but a small quantity grown, only 1868 bales being produced in 1920, and it commands a much higher price than ordinary cotton. Goods made from this fiber are usually so labeled, as the name *Sea Island* stands for quality.

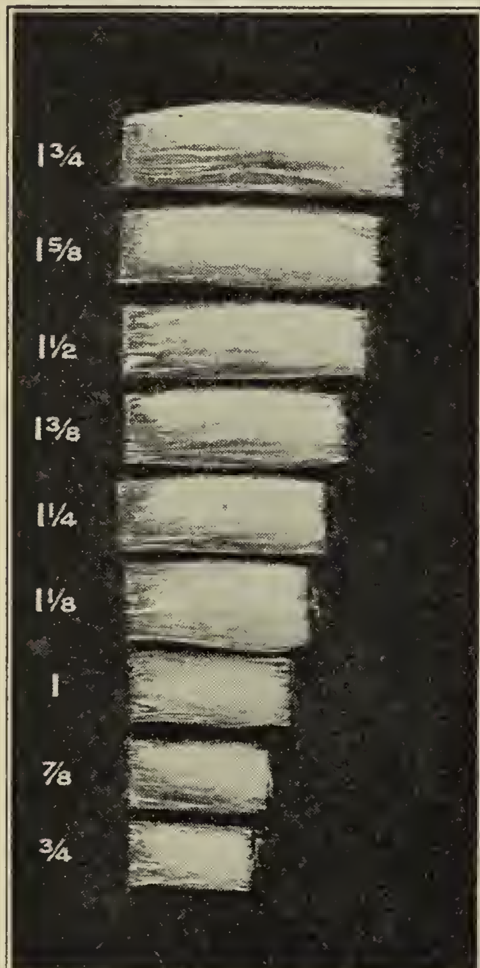
BUDS, BLOSSOMS, AND FRUIT OF THE COTTON PLANT

Courtesy of Guaranty Trust Company of New York

2. *Egyptian.* In order of excellence the next variety of cotton is the Egyptian, which we must import. Egyptian cotton is a strong, silky fiber shorter than the Sea Island, averaging from $1\frac{1}{4}$ to $1\frac{3}{4}$ inches, and is of a creamy color. It is supposed that the color is caused by the brown mud on the banks of the Nile where it grows. This yellowish tinge does not bleach out easily, and for this reason Egyptian cotton is used mostly for those materials which are dyed or are to remain a creamy color. Egyptian cotton is used much in knitted underwear and stockings. Balbriggan underwear was formerly always made of Egyptian cotton.

This kind of knitted underwear has been known for a long time but is now becoming little used. It always has a yellowish tinge and

was formerly very strong and enduring. At the present time balbriggan goods may be made of any kind of cotton and dyed to color, thereby rendering it no more enduring than ordinary cotton materials.



LENGTHS OF COTTON STAPLE

Courtesy of United States Department of Agriculture

3. *Upland.* The great bulk of our cotton goods is made of upland cotton, the variety that our Southern states produce in great quantities. Upland cotton grows in North and South Carolina, Georgia, Mississippi, Louisiana, Texas, Tennessee, and Arkansas. With the exception of the small quantity of Sea Island cotton and less than 100,000 bales of American-Egyptian, a recently introduced variety, the entire American crop of over 13,000,000 bales consisted, in 1920, of this variety. The staple[1] of the upland cotton is shorter than that of either the Sea Island or the Egyptian, varying from $\frac{3}{4}$ to $1\frac{1}{4}$ inches; but it is a strong, white fiber, uniform in twist, and spins very satisfactorily. Most of our cotton fabrics, including all the common varieties of unbleached, bleached, dyed, and printed cottons, are made from upland cotton. It is the lowest-priced cotton of the three which allows these staple goods to be sold at a very moderate price.

4. *Peruvian.* Another variety of cotton that we import and use to some extent in this country is Peruvian cotton.

[1] A term used for *fiber* when measured in a mass.

It has a strong staple from 1 to $1\frac{1}{4}$ inches long, is a coarser cotton than the three kinds already named, and feels harsh to the touch. Its principal use is to combine with wool for materials that are to be mixtures.

A COTTON PLANT

Courtesy of United States Department of Agriculture

Production of cotton. 1. *Growing.* Although the labor of producing cotton is less in amount and more agreeable in kind than that required for the production of some of the other textile fibers, there is much hard work connected with cotton raising. Cotton fields must be prepared and planted every year; the young plants must be kept free from weeds by frequently hoeing, or "chopping," the crop, and the picking begins in August, when the bolls begin to ripen, and continues until nearly Christmas time. Cotton plants grow to the height of from four to six feet (or more, depending upon the variety) and bear, like the strawberry plant, blossoms and fruit at the same time. As the plants grow until killed by the frost, they continue to produce blossoms and unripe bolls at the time the ripe bolls are ready to pick. The blos-

soms are very fragile and short-lived. Southern children have a pretty little song that well describes their appearance and character:

> First day white, next day red,
> Third day from my birth I'm dead;
> Though I am of short duration,
> Yet withal I clothe the nation.

2. *Picking.* Because of the seeming impossibility of inventing a picking machine which can discriminate between the ripe and unripe bolls, and which can go through the cotton fields without injuring the delicate buds and blossoms, cotton is picked by hand. While picking can be done by almost anybody, from a little child to an aged person, it is not as easy to harvest a cotton crop at it may seem. The cotton lint must be torn from its case and kept free from leaves and sticks. It must be picked when perfectly dry, which means in the hottest part of the day. It must be gathered at just the right time, before the wind has a chance to scatter the fluffy seeds. During the picking season, which begins as soon as the first bolls ripen, the cotton fields are alive with human workers. Schools are closed and other work neglected at this time, while all members of the family, from the oldest grandfather to the youngest grandchild, are to be found in the cotton fields. Cotton picking means hot, monotonous, continuous labor, and good pickers average only from 100 to 200 pounds a day, this weight always including the seeds, which give two thirds of the whole weight. Formerly, in the Southern states where cotton is grown, the picking was done by negroes who were owned as slaves.

3. *Effect of invention of cotton gin.* In the early days of cotton growing in this country, picking was not the only tiresome work connected with this crop. The separating of the lint from the seeds, which must be done shortly after

picking, was a slow, tedious hand process, a good worker being able to clean only about one pound of cotton a day. Until the invention of the cotton gin in 1793, more than 150 years after cotton was first introduced into America, approximately 10,000 bales of cotton were produced annually in the whole country. Eli Whitney's wonderful invention revolutionized

AN OLD-TIME COTTON-PICKING SCENE

Courtesy Amoskeag Manufacturing Company

the cotton industry and caused it to become a great factor in the social, industrial, and financial history of the world. The cotton gin so stimulated cotton growing that in 1810, seventeen years after its invention, the South produced nearly 180,000 bales of cotton, and a noted Englishman[1] made the prophetic remark, "It is probable that the clothing of this small seed will become the principal clothing of mankind."

The invention of the cotton gin was to have a more far-reaching influence, however, than the increase of cotton pro-

[1] Dr. Erasmus Darwin.

duction in the South. Up to this time slaves had been kept and used in both the Northern and the Southern states, though the greatest number were always found in the South, where large crops of tobacco, rice, and indigo were produced. In the few decades before Whitney's invention the principle of slavery had been growing more and more distasteful to the American people, and state after state made laws prohibiting the importation of slaves. Only six years before the appearance of the cotton gin the entire South voted unanimously against the extension of slavery. But with the sudden and unprecedented increase in cotton growing, caused by Whitney's invention, the South saw no other way of carrying out the possibilities so alluringly opened up, except by slave labor. In the ten years between 1790 and 1800 the number of slaves in the Southern states had increased nearly 33 per cent, and at the end of the next ten-year period (in 1810) there were more than a million slaves in the Southern states.

Before this sudden growth in cotton production, wool and linen had been the chief clothing of the American people. The name *linsey-woolsey* tells the fibers of which the cloth is made. The making of the cloth had all been done in the home; but with this new fiber produced in such great quantities at their very doors, enterprising men began to build factories in America, and a great impetus was given to cotton-manufacturing abroad. So the lusty infant grew, carrying with it many complicated questions, among which slavery took the lead. By 1860, *King Cotton* was a common expression all over the country; but along with the growth of King Cotton there had developed a situation in the South which was not anticipated at the beginning,—a population of slaves amounting to 4,000,000. No wonder that cotton is sometimes called the cause of the Civil War.

4. *Ginning.* After cotton is picked it is taken to the gin-

nery, where the lint is pulled from the seeds. An up-to-date ginnery can clean 5000 or more pounds of lint a day. The first ginning gives us the fiber that is used in manufacturing the great mass of all kinds of cotton cloth; but as the fibers adhere most tenaciously to the seeds, after one ginning they are by no means free from lint. They are again ginned, producing a considerable amount of short and broken fibers called linters, and this is the cotton used for string and the lowest qualities of cloth, for cotton batting, for mattresses, and, when chemically treated, for gun cotton and absorbent cotton. During the World War all the cotton linters were commandeered by the government.

The cleaned cotton seeds were formerly considered refuse and were burned or used as fertilizer. The familiar names of *cottonseed oil*, *cottolene*, *vegetable oil*, etc. now show us what useful products these seeds furnish. After the oil has been extracted the solid portions of the seeds are made into meal cake or bran, an excellent food for cattle. It is estimated that the value of the cotton crop from the seeds alone amounts to $384,000,000 annually.

5. *Baling, shipping, and storing.* After ginning, cotton lint is compressed into rectangular bales of 500 pounds each, covered with burlap sacking and bound by iron bands. These bales are then taken to the nearest port from which the cotton is to be shipped to its final destination. Charleston (South Carolina), Savannah (Georgia), New Orleans (Louisiana), and Galveston (Texas) are the largest cotton ports of the South, and the wharves and docks of these cities at certain times seem to be a veritable sea of cotton bales. From these ports the cotton is taken to our Northern states or abroad for manufacture. New York City and Liverpool (England) are the two great ports where cotton is received for distribution, and they rank as the leading cotton markets of the world.

America has always been very wasteful with her cotton crop, much cotton being lost by poor methods of baling and shipping. The bales of cotton are often obliged to wait months for shipment from the Southern ports, and it has been the custom to allow them to stand on unprotected wharves and in open freight sheds, exposed to the elements and making a most dangerous fire hazard. When buyers examine the contents of a bale they tear a hole in the weak sacking and pull out a handful of cotton, leaving the ragged hole with the lint hanging out to get soiled and become useless for manufacture. This method of sampling still further increases the fire risk. It is estimated that in normal times there is an annual loss of $70,000,000 through such careless handling of the baled cotton. To correct these evils, up-to-date warehouses are being built in the South and better methods of baling are being encouraged. New Orleans has recently constructed the largest cotton warehouse in the world. It has a storage capacity of 425,000 bales and an annual handling capacity of 2,000,000 bales.

© Keystone View Co.

THE POOR BALING OF OUR COTTON IS SHOWN HERE

6. *The boll weevil.* Early in the chapter we spoke of

plant life as being attended by fewer hazards than animal life. In raising cotton there are hazards of blight, wilt, drought, and occasional unfavorable climatic conditions, but a little insect called the boll weevil is responsible for the greatest losses in the cotton crops. The boll weevil came from Mexico about twenty years ago, and has increased alarmingly in numbers and in area occupied. It is most tenacious of life, insidious in its working, and disastrous to any field of cotton that it visits. Every year Congress adds large sums of money to the amounts raised by the Southern farmers to study and fight this pest. Through these efforts some means of lessening its ravages has been evolved, though it is far from being exterminated. Scientists estimate that Georgia alone suffers a loss of from 200,000 to 300,000 bales every year through the work of the boll weevil. Experience has proved that the early-maturing crops of cotton are safer from this pest than those that ripen slowly, like the Sea Island variety. The boll weevil worked slowly eastward until it reached the section where the Sea Island cotton grows, and has now nearly wiped out the production of this wonderful fiber. From a former yield of more than 100,000 bales there were in 1920 only about 1800 bales produced, and the farmers may stop planting it altogether. We are finding the Sea Island label less and less upon our goods, and, knowing the reason for the shortage, we are no longer surprised that the price of goods made from this fiber remains high. Some wag has said that it is hoped the boll weevil will continue to work eastward and finally jump off into the Atlantic Ocean.

7. *Development of new cotton areas.* The ravages of the boll weevil have, in one way, worked toward the advancement of cotton production. By infesting the regions that have long been used for cotton planting this pest has necessitated the opening up of new sections to agriculture. To-

day vast areas of land that a few years ago were barren and apparently worthless have been rendered highly productive. Through the efforts of the United States government and of private enterprises the immense desert river valleys in Oklahoma, New Mexico, Arizona, and California are now being reclaimed and planted to cotton.

8. *American-Egyptian cotton.* With the wiping out of the Sea Island variety (the only long-stapled cotton raised in America) the Department of Agriculture has experimented with the raising of Egyptian cotton in this country, until a variety of high-grade long-stapled cotton has been evolved, which will grow prolifically here and is now officially called American-Egyptian cotton. It is a strong, white staple, running from $1\frac{7}{16}$ to $1\frac{3}{4}$ inches in length, and produces a high yield per acre. This cotton is especially useful for automobile tires, and some of our large rubber concerns have done much to promote the opening of these areas. The quarantine against the boll weevil has been very strict, and so far this pest has not penetrated into these new localities. With the loss of the Sea Island variety it is probable that this staple will take its place in the manufacturing of fine fabrics, and later on we may see the label *American-Egyptian Cotton* used as a guaranty of quality on our goods as frequently as we formerly saw *Sea Island Cotton.*

Manufacture of cotton. 1. *Yarn.* When cotton arrives at the factory the bale is opened and the fiber picked apart and shaken free of dirt by machines made for the purpose. The tangled mass of fibers is then put through one or more carding machines, where it is changed to a filmy, almost transparent sheet of gauze, which is then run through a trumpet-shaped instrument and enters the drawing frames as a big, soft rope. After passing through many machines this soft rope is drawn, doubled, and condensed until it has been changed to a firm yarn about the size it is finally to remain.

Substantially all long-stapled cotton, like the Sea Island, is not only carded but also combed, and, as machinery improves, it is becoming possible to give this treatment to fibers of shorter and shorter lengths, until now nearly every variety of high-grade cotton may be combed. "Made from combed cotton yarns" is frequently found on the label of many of the better grades of cotton goods in our stores.

During these various processes the cotton receives different names according to its form, as *lap, roving, sliver.* The last machine it is put through is the spinning frame, where the final drawing and twisting take place, producing the specified kind of yarn. Many materials require special treatment of the yarn before it is used for cloth. If lisle, sewing cotton, or fine yard goods is to be made, the yarn must be singed or gassed. All cotton-warp yarns are sized, or "slashed," the amount of stiffening applied varying with the nature of the finished product. The yarns for sewing cotton require much sizing; those for nainsook, little. For some fabrics, as ginghams, the yarn is dyed; in warp-printed materials, like cretonnes, it is printed after it is prepared as warp; and in high grades of knitted goods and certain kinds of woven cloths it is mercerized.

2. *Weaves.* The greatest bulk of cotton cloth is woven with the plain weave. This is an inexpensive weave and insures rapid production of material. Cloths with the simple weave wear well and have the best laundering qualities. The twill weave enters into some classes of goods, as denim and khaki. This weave increases the strength of the cloth. The satin weave is found in sateen, galatea, and others, and is used to increase their beauty as well as make them less susceptible to soilure. The elaborate Jacquard, or damask, weave is found in table damask, white or colored. Pattern, or figure, weave comes in cloths for toilet uses and draperies. It is also used in shirting madras. Pile weave appears in Turkish towels, velveteen, and corduroy; leno and

gauze weave in curtain scrim and marquisette; double-cloth weave in pillow tubing, Marseilles counterpanes, and bathrobe material.

3. *Finishes.* The finishing processes of cotton cloth almost exhaust description. Cotton materials conform to all degrees of stiffness, from the limp surgical gauze to the boardlike buckram. All the different coloring processes are applied to cotton, giving us all styles of piece-dyed, yarn-dyed, and printed materials. The least employed method of coloring cotton is stock-dyeing. This process is used, however, for jewelers' cotton and for mixtures where the combination of cotton with some other fiber takes place in the raw material. Innumerable kinds of finishes are used with cotton, from almost no finish of any kind, except an ordinary washing and pressing, to elaborate finishings which may include many operations and the application of expensive dressings. In short, it seems as if every experiment in textile manufacturing had found a successful fulfillment in the field of cotton materials.

4. *Mixtures.* Because cotton is our cheapest textile fiber and is so adaptable to all kinds of textile treatment it is often combined with other fibers in the manufacture of materials called mixtures or unions. These mixtures greatly increase the kinds and amounts of inexpensive clothing materials and, if the article bought is not misrepresented, are a great boon to the people. Viyella flannel is a more satisfactory wash flannel than if it were all wool, as the cotton fibers twisted with the wool fibers in the yarn increase the strength and reduce the shrinking property of the material. The same thing is true of knitted wool underwear, that which contains cotton wearing more satisfactorily than all wool. High-grade manufacturers often state the percentage of wool and cotton in the garment. Cotton warp in blankets and rugs does not make the articles undesirable, and the cost

is thereby lessened. During the World War the United States government, even though its specifications for cloth making are extremely high and exacting, required cotton to be used in uniform cloth and blankets. Cotton is often mixed with wool in dress materials, suitings, and coatings, thus allowing satisfactory garments to be produced at a lower price than if nothing but wool were used.

Cotton is successfully mixed with silk in plated hosiery, where it forms the inside of the stocking; in satin lining materials, where the face of the goods is of silk and the back of cotton; in goods having ribs, like poplin, where the cotton cord is covered with silk or wool; in materials of plain weave, where one set of yarns is of silk and the other of cotton, as ABC silk; and in some of the cheaper fancy silks, satins, pongees, wool suitings, etc., where cotton yarns are introduced.

Cotton and linen unions are common. They are found in crash, huck, and table damask. In the finer plain linens, like handkerchief linen, the appearance of these two vegetable fibers is so similar that frequently an expert cannot tell without testing whether or not cotton is present. In such materials people, if informed at the time of purchase, do not usually object to the presence of cotton, as the price is thereby lessened. They do object, however, to being deceived and allowed to believe that the material is all linen.

Imitations of other fabrics. Not only does cotton enter into many materials made of other fibers, but many all-cotton fabrics are made to look like other kinds of cloth. The heavy napped surfaces of cotton blankets and bathrobe material make them seem as if made of wool. Mercerization can give cotton such a high luster that it closely resembles silk, as in sateen and soiesette. Highly mercerized cotton damask is a very close imitation of linen, and very few people know that mercerized cotton, instead of linen, is

used in a high grade of men's stiff collars. The names of certain cotton materials help out their resemblance to goods of other fibers, as sateen, silkaline, silkateen, farmer's satin, linene, linon, flaxon, and wool nap.

Home manufacture. Until recent years most of the cotton manufacturing in this country was concentrated in New England. The oldest and largest mills are still there, and the names of the brands of cloth manufactured have become household words. Within recent years, however, mills using cotton have sprung up in all parts of the country. In the Middle West, knitting mills now do a thriving business. Textile factories which are subsidiary to some other industry and make only materials for its use, as cloth for bags and fabric for tires, are scattered throughout the country at points most convenient for the purpose. In the Southern states, near the source of production, great strides in cotton manufacture have been taken. For a long time the South was content to produce the cotton and leave the manufacturing of it to other sections of the country. Since 1905, however, Southern mills have consumed a larger amount of cotton than those in the North, specializing in the coarser styles of cloth. The North still manufactures the finest qualities of materials made in this country, Massachusetts leading all other states in volume of production. Fall River is the largest cotton-manufacturing city in the United States, consuming more than 1,500,000 pounds of cotton fiber weekly. New Bedford leads in the production of fine cotton goods. There are also large cotton-manufacturing plants in other parts of Massachusetts and in Maine, New Hampshire, Rhode Island, and Connecticut. In quality of product, however, New England is beaten by the older textile establishments abroad. American manufacturers have, for the most part, considered it best to keep to that large class of goods required for the practical needs of mankind,—reliable, medium-priced mate-

rials,—and these they turn out in unbelievable quantities. Massachusetts alone manufactures two billion yards of cotton goods each year, producing cloth at the rate of eight miles per minute. But for the finest qualities of ginghams, Swisses, embroideries, laces, etc. we still turn to the highly developed products of England, France, and Switerland.

Effect of fluctuation of cotton prices. We gave as one reason for the popularity of King Cotton its cheapness. Cotton, both in the fiber and in the cloth, is our cheapest textile material, though the price of cotton since 1914 has fluctuated madly. During the World War cotton came into its own. Its use was widely extended and its value appreciated as never before. Mercerized cotton fabric replaced linen for airplanes, millions of yards being manufactured for that purpose. Gun cotton, the powerful explosive used by all the nations, is made from cotton lint, and the quantity of cotton fiber required for ammunition can hardly be imagined. It is estimated that half a bale of cotton is required by a 12-inch gun for every discharge, and a battleship, firing at its greatest capacity, consumes from ten to twelve bales of cotton every minute. Is it any wonder that cotton rose from 7½ cents a pound in 1914 to more than 40 cents early in 1920, and that cotton materials and clothes of all kinds assumed a dignity and commanded a price never before dreamed of?

Because of the unprecedented demand for and increasing price of cotton during the war, cotton growing was greatly stimulated, and in 1920 a bumper crop was produced. But with the close of hostilities, followed by the impoverished condition of the nations abroad which had formerly been heavy importers of cotton, and by the naturally unsettled financial condition of our own country during the period of readjustment, cotton again became affected and this time with serious loss to the planters. There was a sudden falling off in demand, accompanied by a lowering of price, until

some of the crop of 1920 sold as low as 11 cents per pound and to many planters did not pay for the cost of production. The lessened crop of the next year again increased the price, and in the fall of 1921 cotton sold for 23 cents. Cotton, our great American textile crop, is the fiber of the masses, and, as someone has said, "It is woven into the fabric of modern life." It instantly registers world conditions, reflecting in its price and later in its production any serious international strife, business depression, or political agitation. As a vast number of our people are connected with the production, manufacture, and distribution of cotton, more lives and fortunes are affected by unstable conditions of this crop than by those of any other textile fiber.

QUESTIONS AND ASSIGNMENTS

1. Bring samples of, mount, and describe, according to directions in question 9 of Chapter XI, fifteen cotton materials.

2. Name five cotton materials suitable for high-school graduation dresses.

3. What three cotton materials do you recommend for each of the following uses, and why?

   Boys' play suits
   Girls' school dresses
   Women's house aprons
   Lingerie
   Sofa cushions

4. What is one of the highest qualities of gingham made? Where is it made? Width? Price? Give names of two other kinds of gingham.

5. Give the trade names of three kinds of sheeting; muslin; cambric. In what widths does sheeting come? What is the usual width of muslin and cambric?

6. Name and give uses of five kinds of heavy cotton cloth; five kinds of light-weight material.

7. Name twelve cottons with plain weave. Name three cottons with twill weave; three with satin or sateen weave. Name two cottons with Jacquard, or figure, weave; two with gauze, or leno, weave.

8. Get sample of warp-printed cretonne and one of surface-printed of approximately the same quality. Compare appearance and price.

9. Give the names of three stiff cotton materials, three limp materials, and two each of plain-dyed, yarn-dyed, and printed cloths.

10. Give names of three kinds of cotton crêpe materials; three of napped materials.

11. Name three large tire concerns. Where are they located? Which ones grow part of their own cotton?

12. How have the desert valleys mentioned in this chapter been reclaimed? With the use of the Guide to Periodical Literature, find an article on the Reclamation Projects of the United States, and give a report on the article.

13. Get samples of drapery materials named on page 203. Mount and describe.

14. Get one sample each of the following mixtures:

Wool and cotton
Silk and cotton
Linen and cotton
Mercerized and unmercerized cotton
Artificial silk and cotton

15. Look up in a commercial geography the cotton-growing areas of the world.

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See page 369.

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CHAPTER XIII

THE CHANGING OF FLAX INTO LINEN

Exalted position of linen. While our good friend, King Cotton, can entirely fill our needs for garments and house furnishings, the possession of linens always gives the owner a satisfying sense of elegance and refinement. Cotton has become to us the fabric of utility; linen, the fabric of luxury. Linen is an old fiber. The Bible tells how King Solomon had linen yarn brought out of Egypt, and there are still in existence the linen wrappings of mummies thousands of years old. In our own Colonial times nearly everyone raised flax, and the flax spinning wheel is by no means an uncommon relic of those days. At the present time the chief clothing of the peasants of Russia and of some of the other European countries is material made from flax. Why, then, do we consider linen the fabric of luxury if the flax fiber is so old and is still put to such utilitarian purposes by people in other countries?

Arduous labor attending linen production. There are two distinctive reasons for our high appreciation of linen. One is that both the production of the fiber and the manufacture of it into cloth are attended by hard, dirty, and monotonous work. As a consequence little flax fiber is raised in this country, and no fine linens are manufactured here. These cloths must all be imported and are relatively expensive materials. If, however, we could trace a yard of linen through all its experiences from the time it was planted as a seed until it was delivered to a customer over the counter of a store, we should not wonder at its high price. We should, instead,

marvel that enough cloth could be manufactured so that nearly everyone may possess some linen.

Comparison of linen with cotton. Another reason is found in the distinctive characteristics of linen cloth. Fine linens are exceedingly smooth. Who is there who does not prefer the feeling of a fine, sheer linen handkerchief to one of cotton of the same texture? Linen is lustrous. Compare the glistening appearance of linen table damask with cotton damask of the same quality. The difference may not be so marked when both materials are new, but will be more and more apparent with usage. Linen is enduring. Compare the length of life of a cotton with that of a linen handkerchief or of cotton with linen damask. It used to be said that a pair of linen sheets would last a lifetime, — a good testimony of their endurance. Linen is strong. Until near the end of the World War linen fabric was considered the best material for airplane wings. Our strongest threads, cords, tapes, and lacings are all made of linen. Linen is far more absorbent than cotton. There is probably no housekeeper who would not choose linen huck instead of cotton huck for her face towels, and linen crash instead of cotton crash for her kitchen towels. Linen gives up its soilure and stains more readily than cotton and keeps clean longer. Linen has a natural stiffness which is retained to the very end of its life. Can you think of any outer garments that look so fresh, crisp, and cool as a newly laundered linen blouse, dress, or suit? Linen has always represented the symbol of purity. Our Lord's winding sheets were of linen,[1] and the Bride of the Lamb is described as "arrayed in fine linen, clean and white."[2]

1. *Similarities.* To the casual observer the general appearance of linens is very much like that of cottons, and both kinds of material are usually found in the same or neighboring departments of the store. They are both made

[1] Mark xv, 46. [2] Rev. xv, 6; xix, 8.

from vegetable fibers, and their chemical characteristics are similar. Both cottons and linens can be bleached to a snowy whiteness. Both materials endure continued laundering, allowing them to be used for wearing apparel and household purposes where frequent washing is necessary.

2. *Differences.* Their physical characteristics are quite different, however, making linen a much less adaptable fabric than cotton. Flax, being a bast fiber and extending the entire length of the plant, is straight and long, from 12 to 36 inches. These long fibers make a much smoother cloth than can be made from the short cotton fibers, but they also prevent linen cloth from being napped, and the whole field of napped goods is closed to linens. Flax fibers are tough. Linen thread, instead of cotton, is used for sewing articles that are to bear a heavy strain, as army shoes, harnesses, and trunk straps. But linen thread lacks elasticity and is not desirable for ordinary usages. Because they are straight and slippery, flax fibers can be packed together solidly, giving the leathery feel of linen table damask, which cannot be produced by the curly, twisted cotton fibers. Linens are heavy, however, and in the stores where the majority of salespeople are women, men are usually required to handle and sell table linens. This close packing together of the fibers with almost no air spaces between prevents linens from giving warmth. Linen garments are delightful for hot weather, but are less comfortable than those of any other fiber in cold weather. Linen sheets on a winter night do not enfold one in a warm embrace. The flax plant stands stiff and erect without leaning or twining. The flax fiber retains that stiffness, and good linens require little or no starch either in manufacture or usage. A linen bath towel of Terry weave is so harsh that it is more desirable for friction than for drying, and we cannot imagine any of the crêpes or crinkled goods made of this stiff fiber. For garments that

cling or require draping, linen cannot be used. It is the purpose of flax fibers to take up water for the plant, while cotton fibers are made so as to resist water. For all absorbent purposes, therefore, linen is the better material. As the smooth flax fiber gives up stains easily, so linens are prone to give up their dyes. Linens are seldom printed or yarn-dyed. Most colored linens are piece-dyed, and when we buy them we are never quite sure that the color is fast. The bright borders of towels and table linens are usually of cotton.

Limitation of weaves in linens. The characteristics of the flax fiber somewhat restrict the field of weaving in linen material. The plain weave is very common and is used in our great quantities of sheeting, crash, butcher's linen, and handkerchief linen. Much toweling is of the huck and bird's-eye or diaper weave. The twill weave is seldom seen in linens, and the gauze, lappet, double-cloth, and pile weaves are almost never employed with the flax fiber. The weave that seems always associated in our minds with the word *linens* is the Jacquard, or damask, weave. This, as we know, is a variation of the satin weave, of which sometimes a large part of the pattern is made. The name *satin damask* is often applied to cloths of this type.

Production of flax fiber. 1. *Planting and harvesting.* The producing of the flax fiber is a hard, monotonous task. Like cotton, flax is planted and harvested every year, but here the resemblance between the two crops ends. Cotton is planted in hills; flax is sown broadcast. Cotton is a shrub; flax is a grain. Cotton loves the hot, dry climate of the torrid countries; flax thrives only in cool, moist climates. The weeds in the cotton field are chopped out with a hoe; the weeds in a flax field must be pulled out by hand, and the weeders usually work in the field in their bare feet to prevent trampling down or crushing the young flax plants.

This is hard, disagreeable work, and our American farmer likes it less than work that he can do with a machine. Cotton is harvested by hand, but cotton picking is clean work and the harvest season is almost a social occasion with the cotton pickers. Nearly all the people in the community, from the grandparents to the children, gather in the cotton fields in

PULLING FLAX

Courtesy of the United States Department of Agriculture

the picking season. It is hot, tiring work, but there is also much joyousness connected with it. Not so with flax harvesting. Just before the grain is ripe, while the stems are still green, the flax must be harvested,—not by picking a fleecy mass from dry, brown bolls, but by pulling the flax plants up by their roots in handfuls. This is dirty, back-breaking work and can only be done by strong adults. There is no congregating of families in the flax fields, and no social joys accompany the harvesting of the crop.

2. *Rippling.* After cotton is picked, substantially all the hand labor connected with it is finished. The fiber is separated from the seeds by machinery and requires no further treatment by hand until it reaches the factory, to be made into yarn or cloth. After flax is pulled, the disagreeable hand work required to secure the fiber has only begun. The plants must be kept straight, so that the stems will not become entangled. After pulling, the roots are usually rapped against the boot to knock off the dirt, and the flax is spread out on the ground in parallel rows to dry. After a few days the dry plants are drawn by hand through an instrument called a rippler, which removes the seeds, leaves, and small branches at the top. The flax is then tied up in bunches and is ready for the next process, which is peculiar to the production of all bast fibers. The flax fiber is in the stem of the plant, but it is securely protected on the outside by a thin layer of woody tissue, like the bark of a tree. This woody tissue must be completely removed before the flax fiber can be used. The only way of doing this is by decomposition, or retting, as it is called.

3. *Retting.* The rotting, or retting, of flax must be done without injury to the fiber, and while there have been many experiments and some progress in the use of chemicals for this purpose, at the present time the safest and best medium known for the retting process is clear, soft water. Different countries employ different methods of retting. In Russia, where there are vast open acres, the flax is spread out over the fields, and the dews and rains perform the retting process. This is called dew retting, and it takes from three to four weeks for the work to be accomplished by this method. During this time it is supposed that the flax will be frequently turned and inspected to see that no injury to the fiber is taking place; but the Russian peasant does not always give the most careful attention to the process, and

Russian flax fiber does not rank high in quality. In Ireland and some of the other European countries where there are many stagnant pools scattered throughout the flax-growing region, the bundles of flax straw are immersed in these, and watched and turned until the decomposition is completed. This is called pool retting, and is accomplished in from ten

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FLAX RETTING IN BELGIUM

days to two weeks. Usually the fiber that has been pool retted is of good quality. Belgium, however, produces the highest grade of flax fiber in the world, and the perfect method of retting employed is in a great measure responsible for this excellence. Throughout the Courtrai region, where much flax is raised, runs the River Lys, and the retting properties of this river water, combined with the good climate and the industrious and painstaking habits of the Belgian

people, cause the Courtrai flax to be used for the manufacture of the best and finest linens that are made. This method is called river retting, and is accomplished by running water instead of stagnant water, as in pool retting. The bundles of flax straw are placed in large wooden crates, weighted with stones, and sunk in the river. At frequent intervals of time these crates are raised, the flax is turned and inspected, and the crates are again sunk in the river. Great care is taken to stop the retting before the fiber is attacked, and the experienced Belgian people know just when to remove the flax from the water. River retting takes about the same length of time as pool retting. After the flax is retted it must be thoroughly dried, and then it can be stacked and kept for any length of time, as is the case with other kinds of straw.

4. *Breaking, roughing, and scutching.* The outside coat of the flax straw has now become brittle and useless as a protection to the fiber within, but it still remains on the straw and must be completely removed before the fiber can be used. Here, again, we have a tedious, dusty process to be performed, with much hand labor. The straw is first run through a machine called a flax brake, which breaks this rotted tissue into small fragments. Then follow many processes called roughing and scutching, the object being to separate the flax fibers and free them of every particle of the rotted woody covering. When flax is cleaned from its woody bark but is still composed of an unopened mass of somewhat tangled fibers, it is called "in the rough" and cannot yet be used for manufacture. The next series of processes is to open up, or separate, the fibers and grade them into uniform size and length.

5. *Hackling.* The flax fiber is, like the long inside fibers of any grass or grain stem, capable of an infinite number of subdivisions. It is possible to split up the fibrous mass into long individual fibers almost microscopic in diameter, and

this is done by a process called hackling. Try to pull out an individual linen fiber from a very fine handkerchief or piece of lace, and see how fine it is. The finest cotton fiber cannot compare in size with it. The amount of hackling that is done to flax, therefore, depends upon the fineness of the material into which it is to be made. The hackling of

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HACKLING FLAX

flax means not only subdividing and straightening the fibers, but also taking out the short, broken, and tangled ones. Hackling is done by drawing the fibers through their entire length over a series of hackles, or hatchels, set with sharp steel pins, or teeth. All the teeth on a hackle are of the same size, but there are many grades of hackles, according to the fineness of the teeth or the closeness with which they are set. The finer the flax fiber is to be, the more hackles (each finer than the one before) the flax is drawn through, until, at the

end of the process, the flax has been changed from a rough, somewhat tangled bunch of fibers, to which small pieces of bark still adhere, to a bunch of straight, clean, soft, and shining filaments. It is now called line, or dressed flax. The natural color of the fiber depends upon the care taken with its production, but that used for fine linens is usually a creamy or light-yellow color. When one sees a bunch of this fine, glistening yellow fiber he understands why little girls with light hair are often called flaxen-haired.

The hackling of flax can be done by machinery, and in cases where the fiber is to be used for coarse and less expensive materials a machine is used for this operation. All the flax for fine linens, however, is still hackled by hand, and this must be done by experienced and skillful workmen, their hand labor adding much to the cost of this class of materials. The line, or dressed flax, is now ready to be spun into yarn. Neither carding nor combing is necessary, but these bunches of slippery fibers must be drawn and twisted into a strong, continuous strand of the desired size. Compare the preparation of linen at this stage of manufacture with that of cotton. Do we wonder that linens cost more than cottons?

Making of linen cloth. 1. *Drawing out of flax fiber.* The drawing-out process of the long, straight flax fibers is very different from that of the short, curly cotton fibers. Instead of twining around each other and clinging together like curly hair, as in the case of cotton fibers, the smooth, slippery flax fibers lie close and parallel but independent of each other, like straight hair. The secret of making a uniform yarn of flax lies in lengthening the strand by adding the new fibers gradually so that no bunches or thick places occur. We now see one reason why flax is pulled and not cut. The fibers near the bottom of the plant are at their maximum size. Near the top and in the root they gradually taper off. If the flax were cut off above the root, there would be stiff, square ends

to the fibers, instead of tapering ends, and it would be much more difficult to make a fine and uniform yarn. For drawing out, a certain amount of the line is spread on a board (called a spread board) from which it is taken by means of a traveling apron to the various machines that draw it out and twist it into the different sizes of roving. Upon the worker who tends the spread board much of the uniformity of the finished yarn depends; for, to insure an even run of yarn, he must continue to add new fiber, in just the right amount and at the right time, to that which is constantly being drawn from the board.

2. *Spinning of yarn.* In the further processes of linen manufacture special conditions must be maintained. The flax fiber is a tyrant in the textile world, undemocratic in her methods and inexorable in her demands. She loves moisture, and for good results dampness must accompany all the steps in manufacture. In spinning, the yarn is passed through water, either hot or cold, or is kept moist by the constant dropping of water or escape of steam. In olden times, when the wonderful laces were made that are now found only in museums, the flax was spun and the lace made in damp cellars, because of the nature of these delicate strands. In the flax mills of Ireland and Scotland the floors are always wet, and the operators work in their bare feet.

3. *Weaving of cloth.* The weaving of linens, with the exception of the excessive moisture required in the weaving sheds, is similar to the weaving of other fabrics, but in linen weaving Jacquard looms predominate. Knowing the expense of time and labor required in setting up a pattern in the Jacquard loom, we are not surprised that old patterns like the snowdrop or polka dot in table linens can always be found, nor that there are so many duplications of other patterns. Unusual designs very greatly increase the cost of table damask, and in the trade it is generally understood

that when prices above a certain plane are demanded, the excess is to pay for the design.

4. *Bleaching.* The methods of bleaching have been described in Chapter VIII, but there is much more variety in the methods and amounts of bleaching of linens than of cottons. All the very finest linens were formerly grass bleached and are now partially so bleached. Much linen is, like cotton, wholly bleached by chemicals. Natural-color linen is the strongest kind, and continued launderings will eventually bleach it white. But most people object to natural-color linen for table or toilet uses. So in damasks there are many grades of bleaching, from the creamy, unbleached damasks to the fabrics of dazzling whiteness. It is said that one fifth of the weight of linen is lost in the full bleach, consequently unbleached or slightly bleached linens are much more enduring for hard wear.

5. *Finishing.* In the finishing of linens, there is very little need of foreign substances to give stiffness and luster, and good linens are almost devoid of dressings. The attractive qualities of linens are inherent in the flax fiber and need only the right treatment to emphasize them in the cloth. In ironing linens we know that the stiffness is increased if the iron is very hot and the linen very damp. These principles employed in the home ironing of linens are followed throughout the pressing and calendering operations in the manufacture of damasks. The natural firmness and stiffness of the cloth is further increased by subjecting it to the quick, heavy strokes of a series of hammers. These hammers are set in a roller under which the cloth passes slowly, receiving a rapid, continuous shower of blows. This process is called beetling, and linen may be passed several times through a beetler until every inch of its surface has been vigorously hammered. Beetling permanently flattens the yarns, increasing the luster of the cloth by producing a

greater area for reflection. It also serves to crowd the yarns still closer together, producing the leathery feel that is always found in good damasks. The "round thread" linen, used for articles in which the threads are to be pulled, has not been beetled.

Use of tow. What has become of the short, broken, and tangled fibers that were combed out when the fine line flax was made? Is it of no use in linen manufacture and thrown away? No, indeed! The flax fiber has cost too much in time and labor to throw any of it away after the scutching process. This mass of tangled fibers is called tow and somewhat resembles the uncombed hair of the little boy who is called a towhead. This tow, together with the mill waste of line flax, goes through about the same manufacturing processes as other textile fibers that are short or irregular in length. It is picked, carded, combed, drawn, doubled, and spun very much as is done with cotton fibers, except that much more moisture must accompany the operations. The material made from tow, whether yarn or cloth, is all linen and possesses the characteristics of linen. As it is made of short ends, however, the yarn can never be as smooth, fine, and uniform in size as that made from line. This is the linen that is used for the coarser crashes, for towelings, and for union goods. As the tow is repeatedly combed and the noils thus obtained mixed with more waste and combed again, one sees that there are different qualities of tow products. The cheap linen dish towels or hand towels that shed lint so badly are likely to be made of a very poor quality of tow.

Seed flax. The flax plant bears a very pretty little blue flower ("Blue were her eyes as the fairy-flax")[1] which later on matures into a small round shell containing the seeds. Flax produces two articles of value, the fiber and the seed, but the production of one means the sacrifice of the other.

[1] Longfellow, The Wreck of the Hesperus.

For fiber the flax plant must be pulled before the seeds are ripe, but for seeds the plant must fully mature. A large amount of flax, therefore, may be grown in countries where no fiber but much seed is produced, as in our Middle Western states and in Canada. The seeds are used for medicinal purposes (flax-seed poultices are an old remedy), but their greatest value is in the production of linseed oil for paints.

Countries producing flax fiber. Russia is the land of fiber flax. The climate, soil, and vast agricultural areas in that great country are most favorable to the growth of this plant. With the settlement of its social and political difficulties, and the increased education of its farmers, Russia should outstrip the world in this product. Belgium's rank as a flax-raising country is gained by quality rather than quantity of fiber. France, Germany, and Austria raise flax, as do the British Isles, particularly Ireland and Scotland.

Fiber flax in the United States. Fiber flax will grow in the United States. In Colonial days nearly every farmer raised flax fiber enough to furnish the household linens and linsey-woolsey for clothing. Beautiful old hand-woven linen sheets, towels, and tablecloths are kept as heirlooms in many homes at the present time, and the flax wheel, hatchel, and other flax-working instruments are possessions much prized by the descendants of those old Colonial families. Until 1790 flax and wool were the two textile fibers of our forefathers in this country. But after the invention of the cotton gin linen lost to cotton her supremacy. Within the last twenty-five years there has been much experimentation with the production of fiber flax in the United States. In certain sections, like the upper Central states (North Dakota, Minnesota, Wisconsin, and Michigan) and Washington and Oregon of the Northwest section, the climate, soil, and water seem well suited to the production and cleaning of flax fiber. Some of the fiber produced in these localities has been pronounced by

experts to equal in quality Courtrai flax. With the shortage of this crop, due to the war-devastated flax-growing areas in the European countries, an impetus to American production was given. Until chemicals and machinery can take the place of the great amount of hand labor now required for the production of flax fiber, however, there seems to be no promise of its becoming a crop of importance in the United States. The American farmers demand a much higher wage than the European farmers and cannot compete with them in the price of a crop attended only by hand labor.

Flax-manufacturing countries. The United States has a few flax mills, but flax manufacture in this country is chiefly confined to the making of linen thread, cord, and string. One or two mills make coarse linen toweling, and a few make union goods. Fine linens require special machinery, special conditions, and specially trained workers. In several of the European countries these conditions for manufacture obtain, and there have not yet been sufficiently strong inducements for the United States to compete with those countries. In Russia the linen cloth is mostly a hand-made product. In nearly every Russian peasant's home is a hand loom, and all members of the family take turns in weaving upon it. Russian crash is consequently more durable than beautiful. The irregularity of the weaving is appreciated for the story it tells, and this material is used in house furnishings to give rustic or artistic effects. The linens of Austria and France are noted for their beautiful patterns, those of Germany, Belgium, and Scotland for their strength and durability, but those of Ireland for their uniform excellence. The term *Irish linens* has long meant to linen users cloths of dependability and satisfaction. Belfast, which has earned the title *Linenopolis,* is the great linen-manufacturing center of the world.

QUESTIONS AND ASSIGNMENTS

1. What is a "pattern" tablecloth? In what sizes do they come? In what sizes do napkins come?

2. Is there any difference in price between a pattern cloth and damask of the same width and quality by the yard? Why?

3. How can you tell the right side of damask? Is damask folded with the right side in or out? Why? How wide does damask come?

4. What are the common sizes of huck towels? Compare a linen huck, a cotton huck, and a union huck towel of the same size. What is the origin of the word *huck*?

5. Name some old, well-known brands of linen. Where are they made?

6. What is the origin of the name *butcher's linen*? Why was linen suitable for that purpose?

7. Name three cotton materials that suggest the word *flax* or *linen*.

8. Why are sheets and pillowcases often called bed linen, even though they are made of cotton? What articles are usually kept in a "linen closet"? What is the common name for a linen chest?

9. Why is linen used less for wearing apparel than cotton? Have you any articles made of linen?

10. Mount and describe five linen materials (Chapter XI, question 9).

11. Locate on the map the principal flax-growing areas of the world. Could fiber flax be produced in your locality? Why?

12. Why is linen so much used for church or religious purposes? Find five references to flax or linen in the Bible.

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See page 369.

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CHAPTER XIV

WOOLENS AND WORSTEDS

Common characteristics of wool materials. Wool materials are found in the fleecy bed blanket and the smooth challie blouse, the elegant broadcloth gown and the practical serge dress, the gay tweed suit and the somber army uniform, the heavy steamer rug and the baby's light knitted jacket. All these materials, however dissimilar in appearance, have certain characteristics in common. They are warm, durable, springy, and elastic to a certain extent. They take and hold dye well, do not wrinkle easily, are not especially adapted to washing, and, if allowed to remain cold and wet, will shrink badly.

Source of wool fiber. Cotton is the fiber of utility and linen is the fiber of luxury, but wool is the fiber of comfort. The wool fiber is grown on sheep, and the articles we have mentioned represent the covering of the sheep changed into the clothing of man. When the fiber is worn by the sheep it is called a fleece. When it is manufactured into cloth to be worn by man it is called a woolen or worsted.

It is said that there are over four hundred kinds of sheep in the world. Some are large and others are small; some have long hair and others short hair. On some sheep the fibers are tightly curled, while on others they are little curled. Regardless of the many differences in sheep, however, it is from the fibers grown on their bodies that all the woolen and worsted cloth in the world is made.

Wool-producing countries. The natural home of sheep is in the temperate zone, and they are widely distributed over a large part of the world's area in this latitude. They are found to some extent, however, in the mountainous regions of the torrid zone. They live by grazing and thrive best on wide, open ranges. For this reason those countries where such conditions abound are the ones that produce the greatest amounts of wool. Australia and New Zealand have vast areas of grazing lands unbroken by settlements, and for years these island countries have furnished about two thirds of the world's wool supply. The southern parts of South America and Africa possess similar climatic and physical conditions, and these two sections produce large quantities of wool. In the United States, which ranks third as a wool-producing country, most of the sheep are now raised in our Western states. Until a few years ago those states contained vast areas that were used only by the sheep and cattle men. The United States government allowed free ranges, and large flocks of sheep could be raised with relatively small expense. But with the rapid settlement of homesteaders, the withdrawal of free range lands, the setting apart of great sections throughout the West for national parks, the granting of water-power privileges, and the carrying-out of reclamation projects the easy days of sheep raising in this country are fast disappearing.

Difficulties of the wool grower. Wool and cotton are our two great American textile products. In Chapter XII we learned of some of the obstacles encountered in cotton growing which reduced, and at times jeopardized, the entire crop. Wool growing, too, is attended by dangers and discouragements. Sheep run together in flocks, and in large open areas a flock may contain several thousand sheep. These flocks must, of course, always be kept where there are food and water, so a long-continued drought in the summer

may work utter ruin to the sheep raiser. In the winter either the sheep must be where they can nibble enough grass for their sustenance or they must be fed with hay. It is customary for the flocks of sheep to be driven from place to place in the grazing season, frequently climbing the mountain

THE LONELINESS OF THE SHEPHERD'S LIFE CAN BE IMAGINED FROM THIS SCENE

sides in the summer time and returning to the sheltered valleys for the winter. Their heavy coat of wool protects them in the dry, cold weather, but sheep cannot well endure a heavy blizzard or a long, cold rain. On many ranches sheds must be built to protect the sheep from violent storms.

Sheep are helpless, dependent creatures and fall an easy victim to predatory wild animals. "While shepherds watched their flocks by night" is as true now as in Bible times, and

the sheep herder must give unceasing care to his flock. In his untrained state the dog is the natural enemy of sheep, and the havoc caused by dogs is partly responsible for the discontinuance of the farm flocks. The trained collie or sheep dog is a great protector of sheep, and one man with his dog assistants can usually take care of a large flock. The shepherd makes his home in a wagon in which he keeps a supply of food, and he stays with the sheep constantly. He drives them from place to place in search of the best grazing, protects them from accidents and enemies, keeps a sharp lookout for parasites and disease, takes care of the young lambs, and seeks a place of shelter for the flock in times of extreme weather. The free and easy life of a shepherd may sound picturesque in fiction, but it is a life of almost unbearable monotony. For weeks at a time this solitary man does not see another human being, and it is not uncommon for a sheep herder to lose his mind as a result of these lonely vigils.

These are only a few of the difficulties of the wool grower. There are many more problems that must be met and overcome before this fiber of warmth and comfort can be produced. Woolens and worsteds of high quality can be made only from wool fiber of high quality, and such fiber is grown only by contented and well-cared-for sheep.

Double purpose in sheep raising. The purpose in raising sheep is twofold. The wool is valuable as a covering for man, and the flesh is valuable as a food. It is a fact, however, that the excellence of either of these products is attained at the expense of the other. The sheep that produce the highest quality of wool generally give a small amount or a low quality of flesh, while those producing a high grade of lamb and mutton supply a lower grade of wool. Sheep breeders usually aim to attain one or the other of these purposes, and in Australia and New Zealand the amount and quality of wool has been the end sought. No other sheep-

A FLOCK OF SHEEP WAITING TO BE SHORN

raising section of the world has reached the standards in wool growing that these countries have attained. On our Western ranges also the aim has been the production of wool, and it is of good quality; but the Americans have never devoted as much time and study to the sheep industry as have the Australians and New Zealanders. The main object of sheep raising in Great Britain and in most of the continental countries is for the flesh, and a taste of English mutton proves how well one country has succeeded. Because the sheep must be well cared for and kept in a healthy condition to produce good mutton, the wool produced in Great Britain is live, healthy, and fair in amount and quality. But as the demand upon both the meat supply and the wool supply of the world is growing more insistent every year, the attempt of far-seeing men everywhere in the sheep-raising industry at the present time is to develop a breed that shall produce both satisfactory mutton and satisfactory wool.

Sheep raising in the United States. The United States is seriously interested in this problem of developing a different breed of sheep, for with the contraction of the Western ranges the decrease in our wool production presents an alarming outlook. In the early days of our country good-sized farm flocks were kept by the colonists throughout all the states along the Atlantic coast. Sheep have been raised to a considerable extent in the Central states, and Ohio has for a long time produced some of the best wool in the world. In 1920 Ohio ranked third in the United States in quantity of wool produced, Idaho ranking first, with Montana a close second. But with the growth of commerce and manufacturing instead of agriculture throughout the East, the vast increase in cotton raising in the South, and the opening up of government lands in the West a few decades ago, sheep raising, with some exceptions, passed from the Eastern states to those west of the Missouri River, and the pro-

duction of wool was the chief aim sought. Now that the Western areas are becoming more and more restricted, our sheep-raising industry is declining, and the Federal government is making conspicuous efforts to encourage the restoration of farm flocks. A breed of sheep that would produce both satisfactory wool and good mutton would be by far the most profitable kind for such small flocks.

A MERINO SHEEP

Courtesy of the National Wool Growers Association

Typical breeds of sheep. The highest grade of fiber for woolens comes from the pure-blood Merino sheep. The first importation of these sheep into the United States was during the year 1800, when forty-five were brought from Spain to New England. They sprang into immediate popularity, and in forty years there were millions of these sheep in New England and the Middle Atlantic States. They have also been introduced into Australia, New Zealand, South America, and Africa. Their wool is fine, soft, crimpy, uniformly covered with scales, and from 2 to 4 inches in length. The Merino sheep is a small animal, and its mutton value is low. Sheep breeders have since found it more practical to cross the Merino with larger, meatier sheep, and the expressions *half blood*, *three-quarters blood*, *three-eighths blood*, etc. originated from the amount of Merino strain in the new breeds developed. There are many breeds of sheep that produce

long fibers for worsted or combing wools, but the Lincoln and Leicester, so popular in Great Britain, are particularly satisfactory. They have a uniformly strong, lustrous wool, sometimes more than a foot in length. This wool spins easily and always retains its gloss. Between these two extreme types—the short-fleeced Merino and the long-fleeced Lincoln and Leicester—there are innumerable other breeds which produce wool of varying degrees of length and fineness, all of which is good clothing wool if the breed is carefully selected and the sheep have good care. In America and Australia the Rambouillet is a favorite, while in Europe and Great Britain different breeds are raised in different localities because of some real or fancied advantage to that particular section.

A LINCOLN SHEEP

Courtesy of the National Wool Growers Association

Whatever the breed of sheep or the length of fiber, clothing wools must have certain characteristics to produce a high quality of cloth: the fibers must be live, bright, strong, of good color, and free from foreign substances. Only such wool will spin well, dye well, and produce strong cloth. The dull, dead fiber showing weak places, having a stained or brownish color, and filled with tangles, knots, and burrs can be and is used in manufacturing, but the wool sells for a lower price, is more difficult to manufacture, and does not produce the best class of goods.

Carpet wools. In the manufacturing field all wools are classified into clothing wool and carpet wool. These two names signify not so much the products to be manufactured as the nature and character of the wool fiber. The many kinds of sheep in the world are raised under widely different conditions. In China, Turkey, Russia, Asia Minor, and other less progressive Asiatic and European countries the sheep have reverted more nearly to original type and are almost goatlike in their habits and characteristics. This is also true of the sheep found in and around Peru. They receive little care and for the most part shift for themselves. They are hardy, being obliged to endure rigors of climate, but their fleece is unkempt, torn, dirty and imperfect. The wool from these sheep is long, coarse, harsh, and wiry as compared with wool produced in the younger sheep-raising countries, and is called carpet wool. Carpet wools are strong and enduring and are used for materials where harshness and coarseness of fiber are no detriment and perhaps may be an advantage. For rugs, carpets, coarse and heavy blankets, felt boots, and low grades of wool clothing a valuable addition is made to our wool supply by this variety of fiber. The production of carpet wool, however, seems neither interesting nor profitable for the more progressive countries, so none is produced in the United States or in the other large sheep-raising countries.

Combing and carding wools. Wools are classified by the manufacturers into combing wools and carding wools (or clothing wools), in preparation for the manufacture of worsteds and woolens. The differences between these two classes of cloth are due, therefore, not only to the wool manufacturer but also to the sheep raiser. It was formerly true that all cloth made of wool was called woolen cloth, and many people of today think this condition still exists. Nowadays, however, when a man buys a suit, the

intelligent salesperson tells him, "This is a good worsted," or "We have a line of fine woolens," thus discriminating between the two classes of cloth. Serges are often advertised as worsted serges, and broadcloths are spoken of as soft woolens. Wherein does the difference between woolens and worsteds lie? Roughly speaking, the first difference between them lies in the length and character of the wool fiber of which they are made. Worsteds are generally hard, firm cloths, such as the many worsted suitings for men and the voile, panama, and hard serge for women. Worsted cloth is strong and enduring. It "stands up," as we say, and holds its shape. It does not wrinkle easily, but quickly springs back into place after being creased. For this reason it rebels against draping and adheres to firm, straight lines. The weave usually shows plainly, and the surface of worsteds is practically free from nap or fuzz. These cloths are much more resistant to dust and dirt than woolens,—frequent brushing usually keeping them clean, while woolens often require a wet cleaning. Worsted materials are made of the longer, coarser, and straighter wool fibers having few scales, and these wools are classed as combing wools.

Woolen materials, on the other hand, are warm, fuzzy fabrics, such as broadcloths, flannels, tweeds, fine blankets, and wool knitted underwear. Heavily shrunken cloths, as felts and heavy coatings, and materials with a pile or nap, as chinchilla and bolivia, are found among the woolens. The lighter-weight woolens usually drape beautifully, but wrinkle easily and shrink badly. Woolen garments are elastic and comfortable, but if loosely woven may stretch out of shape. Frequently the weave is entirely obliterated by the excessive fulling and napping. The shorter, finer, and crimpy wool fibers, thickly covered with scales, are used in the manufacture of woolen materials and are classed as carding or clothing wools.

Wool from field to factory. 1. *Shearing and skirting.* From the time it leaves the back of the sheep to the time it becomes clothing for man wool passes through many operations, and the quality of the garment we buy depends to a great extent upon whether these operations have been carefully and intelligently or carelessly and ignorantly

A SHEARING SCENE

Note the wool sack suspended from the frame

performed. The first operation is cutting the wool from the live animal. This is called shearing, and was formerly done by hand with big "sheep shears," but at the present time it is done almost entirely by electric clippers. There are men in the sheep-growing countries whose sole business is sheep shearing, and one of these men can shear from 175 to 200 sheep in a day. In the hot localities they begin shearing very early in the spring and continue to work north as the season advances, shearing the sheep in the cooler sections much later in the season. Sometimes they return to the South and again

shear in those climates where the hot weather continues until late fall. The wool of a sheep usually hangs together in one big mat and is called a fleece. Each fleece is rolled and tied into a separate bundle before being tramped down into the big burlap sack that is to contain the bale of wool.

These are the main steps in the operation of shearing, but all sorts of accessory operations can increase or decrease the value of the wool clip, as these collective fleeces are called. In some places the sheep are dipped or washed before they are sheared, thus rendering the fleece cleaner and freer from foreign matter. Each fleece may be "skirted" before being rolled up and tied. Skirting means removing from the edges of the opened fleece the torn and ragged parts, together with some of the stained and broken locks (taglocks, they are called), that are always found on the belly and around the tail of the animal. When fleeces are skirted, these fragments are all thrown together and baled separately, to be sold as a lower quality of wool. In all cases the fleeces are roughly graded into clothing or carding wools and combing wools, but at some shearing sheds the fleeces are graded into several classes of each, according to the quality of the fiber.

2. *Tying and baling.* The tying of the individual fleeces has a perceptible effect upon the value of the wool clip. Where much effort is taken to produce a clip of high value no string is used for the purpose. The fleeces are cleverly rolled and tied with their own fiber. In the United States sisal cord has been extensively used for tying fleeces. There is strong objection to the use of this string, as it always adds to the weight of the fleece, and frequently many of its sharp, harsh fibers become entangled with the wool, decreasing its value. In Australia and New Zealand great care is taken with the fleeces at the time of shearing, and the wool of those countries maintains a uniformly high quality and commands a good price.

Wool is baled in huge burlap sacks about eight feet long. At the time of shearing, these sacks are suspended from a high beam so that they just escape the ground, and the fleeces are thrown in. After the sack is partly filled, a man jumps in and tramps down the wool. This is hot, disagreeable work, very unlike the machine compressing of cotton, but thus far no better way of baling wool has been devised.[1]

HAULING THE WOOL TO MARKET

3. *Marketing.* The bales of wool, which in the United States weigh from 300 to 400 pounds, are closed at the top and are then shipped to some local market where wool buyers may come to examine and buy the wool. Casper (Wyoming) and Billings (Montana) are large local wool markets. Much of our wool, however, is shipped to Eastern warehouses, where it is graded and held for sale. Boston, the second largest wool market in the world, has a warehouse that will

[1] In her book "Ramona" Helen Hunt Jackson gives a very graphic picture of sheep shearing.

safely store 100,000,000 pounds of wool, or about one third of our average annual clip. Boston is the great wool center of this country, and New York, Philadelphia, and St. Louis are also large American wool markets. Almost none of the wool in other countries is sold in this way, however, but by auctions sometimes held far from the place of production. Series of these auctions are held in London, Liverpool, and Sydney every fall, and most of the wool of Australia, New Zealand, Africa, and South America, as well as that grown in the neighboring regions, is sold at these auctions.

Wool manufacture. Woolen and worsted mills are widely scattered throughout our country, though the greatest amount of wool manufacturing is concentrated in Massachusetts, Rhode Island, and Pennsylvania. Many mills perform only one operation and turn out only one kind of product, as worsted "tops" or woolen or worsted yarns. There are, however, a number of plants in the East that not only perform all the operations necessary to change the wool fleece into cloth but operate both woolen and worsted mills and make the two classes of material. The first processes that all wool fiber must undergo at the factory, whatever the nature of the finished product, are substantially identical.

1. *Sorting.* The bales must be opened and the fleeces must be taken out and separated. The wool on different parts of the sheep's body varies in length and quality. That on the sides and shoulders of the animal is best, while that around the head, belly, legs, and tail is inferior in kind. In the fleeces of combing wools there are parts that cannot be used for combing, and in the fleeces of carding wools there are several grades of the fiber. Each fleece, therefore, must be spread out and torn into several parts (usually four or five), which are thrown into separate bins, each kind to be used for a different purpose. This operation is called sorting, and the men or women who do it get to be very skillful and can tell

at a glance just where to tear apart the fleeces. The quality of the finished cloth is thus affected by the sorting process.

2. *Scouring.* The next operation after sorting is scouring. Wool is greasy, dirty, and sticky when taken from the sheep's back, and this dirt and grease must be removed and the wool rendered clean and white before it is carded. The scouring process is usually performed by means of four connecting tubs, each containing a cleansing bath of a prescribed temperature, in which is dissolved enough potash, soda, or other dirt-removing chemicals to entirely remove the grease and dirt. While in the tubs the wool is kept constantly in motion by automatic rakes and is passed in this way from one tub to the next through rollers which squeeze out the water. In the first tub the wool enters in dirty, greasy masses. It leaves the last tub and enters the hydro-extractor, or drying machine, as the soft, white wool that we see in wool wadding or in the napped surface of our fluffy wool blankets. During the scouring process the wool loses in weight. This loss is spoken of as the "shrinkage" of

© Keystone View Co.

SORTING WOOL

wools, and while that loss in weight varies from 20 per cent in some kinds of wool to over 80 per cent in others, the average shrinkage is about 55 per cent. Wool is usually bought "in the grease," so the price that is paid per pound for the fleece is always in anticipation of the probable shrinkage. At some factories the grease is sold for axle grease, for making soap, or to be converted into lanolin, a substance used for medicinal purposes; but in many cases the wool grease removed by scouring is still a waste product. Australian and New Zealand wools surpass those of the United States because of the cleaner fleeces, which have a lower percentage of shrinkage. After scouring, the wool may be dyed, stock dyeing being more common with carding than with combing wools.

3. *Oiling, blending, and carding.* Whether the scoured wool remains white or is colored, it has been entirely deprived of its natural grease and, if manufactured in this dry condition, will tangle and break easily like long hair after a shampoo. So the next step in the manufacturing process is oiling. The fact that vegetable oil is used for this purpose seems strange, but it is true. It is said that a fortune awaits the man who can invent a method by which a sufficient amount of the natural wool grease can be retained on the fiber to allow its manufacture. But the inventor has not yet appeared. An operation called blending or mixing is usually done at the same time as the oiling. This consists of mixing the various kinds of wool, or colors of dyed wool, or other fibers with wool, according to the specifications of the yarn or cloth to be made. Blending is more common in the manufacture of woolens than of worsteds. The mixing, or blending, process is a most important step in wool manufacture and, when performed honestly, much improves the character of the yarn and cloth produced. For worsted yarns the blending is usually of different kinds of high-grade wool, but for woolen yarns the blending may mix together foreign fibers as

well as a wide variety of wool fibers. In the blending the noils that come from worsted combings are used, and the waste from the woolen and worsted manufacture. Here is where the inferior wool from the fleeces, such as the skirts, the stained, weak taglocks, and the wool from unhealthy sheep or those that have died from disease can be entered.

After the next step in manufacture, which is carding, the treatments that are common to all wool fiber, whether for woolens or for worsteds, have been performed.

4. *Combing of worsteds.* Combing, the one operation in the manufacture of wool that most differentiates woolens and worsteds, enters at this stage. To further mix and straighten the fibers, the carded wool is doubled and drawn through the teeth of machines called gill boxes, from which it is delivered to the comb. This machine forms of the longer, parallel fibers a soft rope, which it proceeds to wind into a big ball called a top. On one Noble comb several of these balls can be formed at once, and worsted tops are frequently the only product of a mill. The short and tangled noils which are combed out, even though they may be new wool of high quality, are of no further use to the worsted manufacturer.

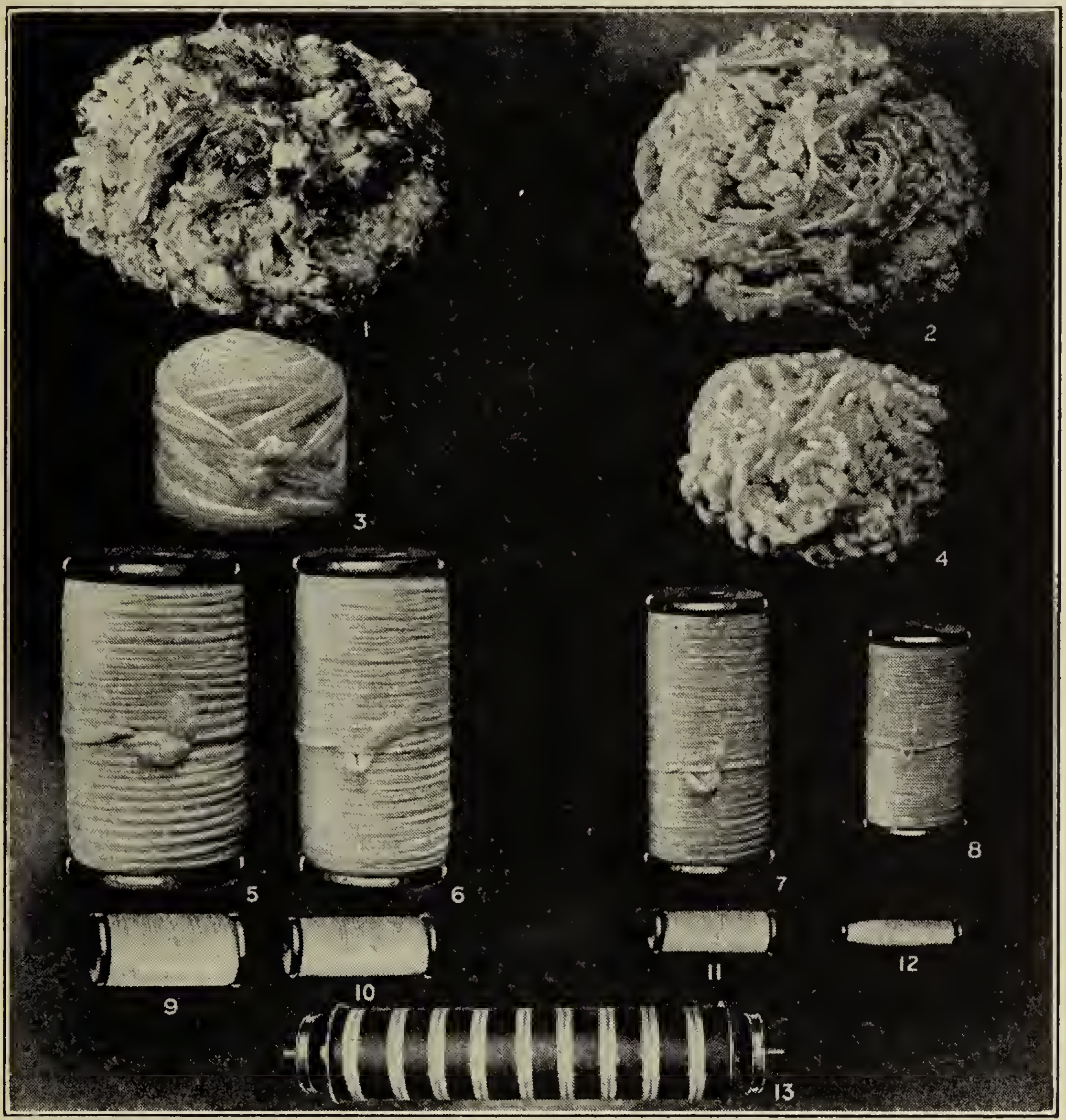
5. *Drawing and spinning.* The operations that follow, to the time the woven cloth is taken from the loom, are similar in kind for the two classes of cloth. After the wool has left either the card or the comb, it passes through various drawing, doubling, and twisting machines before it is ready for the spinning frame. Woolens are usually spun on the mule, and worsteds on the ring spinning frame, but there is no arbitrary rule governing the method of spinning. The results desired are a smooth, strong, rather tightly twisted yarn for worsteds, and a fuzzy, less tightly twisted, and more elastic yarn for woolens, and any method of spinning is employed that will satisfactorily produce these yarns.

Stock dyeing more often takes place with wool than with any other fiber, but dyeing may be done at any stage of the yarn-making or cloth-making process. For certain grays (Vigoreux mixture) the slubbing is first dyed a tone of gray and then printed across with black bars. For all wool cloths in stripes, checks, and plaids yarn dyeing is common, and it is also used in mixtures of cotton and wool, silk and wool, and artificial silk and wool. Plain colored materials are often piece dyed.

6. *Weaves.* The twill weave and its variations are most frequently employed in worsted cloths. This weave is not only more decorative than the plain weave but it makes a firmer, closer cloth. Among woolens the plain weave is usually found.

Finishing of woolens and worsteds. Another great difference in the manufacturing of woolens and worsteds lies in the finishing methods. The development of the particular characteristics of each class of cloth has been the aim of the manufacturer from the time he selected his wool in the market until in the woven cloth he is able to give the final touch to the accomplishment of his purpose. The finishing processes of worsteds are to make the face of the cloth hard, smooth, and firm, clearly displaying the weave. Colored designs show distinctly in worsteds. After being well scoured and shrunk, the cloth is stretched, steamed, brushed, clipped, and pressed repeatedly, until its appearance in every way fulfills the standards required.

The finishing of woolens is usually a longer process than that of worsteds, as the aim with this class of materials is to conceal the weave and render the pattern indistinct. Because of the looser construction of the yarn, with the fibers lying at angles to each other, instead of parallel, as in worsteds, the shrinking power of woolens is much greater than that of worsteds, as has been explained in Chapter XI.



WORSTED YARN IN DIFFERENT STAGES OF MANUFACTURE

1, fleece of Australian wool; 2, scoured wool; 3, combed wool—a top; 4, noil; 5, first drawing process; 6, second drawing process; 7, third drawing process; 8, fourth drawing process; 9, fifth drawing process; 10, sixth drawing process; 11, twisted yarn; 12, spun yarn; 13, warp ready for loom.
Courtesy of the Cleveland Worsted Mills Co.

To increase the weight and closeness of the cloth, flocks are often worked into the interstices of the woven yarns as the cloth is being shrunk. With heavily milled cloths it is quite impossible to distinguish the character of the weave or to separate clearly one yarn from the others, as is proved by the examination of heavy broadcloth. The napping of woolens still further adds to the confusion of the weave. Flannels are usually napped a little, broadcloths more, and such woolly materials as fleecy blankets a great deal. Teazels are still the most satisfactory implements for pulling the wool fibers to the surface, and in fine broadcloths and other light-weight napped woolens they are always used. The clipping of the nap on the surface of the cloth gives the flocks which have been mentioned.

In wool materials the finishing process works an almost miraculous change in appearance. To the casual observer there is little resemblance between the dirty, rough, yellowish-white cloth that comes from the loom and the soft, lustrous broadcloth or the smart-looking suiting that we see displayed on the counter. When we watch the many vigorous treatments to which the cloth is submitted, we no longer question the strength or endurance of the wool fiber.

Not all cloth made of wool is wholly worsted or wholly woolen. In the making of wool fabrics all sorts of variations take place. Worsted yarns are often used for the warp in cloth and woolen yarns for the filling, and vice versa, so that the serge or suiting we buy may be a combination of the two yarns. Woolen materials formerly predominated, but now worsted cloths form by far the largest class of wool goods for civilian uses. This is a fortunate circumstance, as the meatier sheep—toward which most sheep breeders are aiming—produces a high grade of combing wool.

Remanufacture of wool. If all the worsteds and woolens in the world were made from the new fiber taken from the

backs of the sheep—virgin wool, as it is called—our brief story of these cloths would be finished. But such is not the case. In fact, only a little more than one half of the wool made into fabrics is virgin wool. We all know that woolens and worsteds, if of good quality, endure hard wear for a long time, and as long as a fragment of the material remains it retains its original warm, elastic qualities. Because of this tenacious character of the fiber there is a manufacturing process employed with wool that is not used to nearly the same extent with any other fiber. This process consists of tearing out from woolen and worsted cloths the individual fibers of which they are composed and again manufacturing them into cloth. This is what happens to the small pieces of wool material left after cutting out garments (tailor's clippings, they are called), to the wool stockings or underwear that have passed beyond the mending stage and been discarded, and to the dirty old wool rags of all kinds and descriptions that the junkman collects and sells. The United States imports thousands of dollars' worth of wool rags every year for the purpose of reclaiming the wool fiber. These rags come from all over Europe, and Dewsbury, England, is the great rag market of the world.

1. *Sorting and grading of rags.* Reclaiming wool fibers is an interesting process and is sometimes done by the manufacturer who is to use the wool thus obtained in his new cloth, or it may be done by a separate company and sold to the cloth manufacturer. In any event the processes of reclamation are practically the same. The first step is the sorting or grading of the rags. This is done most carefully, and many classes of rags are obtained, each to yield wool for a definite purpose and to command a specific price. Familiarity with the manufacture of woolens and worsteds shows that the fiber can most easily be extracted from woolens, and soft white knitted goods bring the highest price in the rag market.

After the rags are classed they are subjected to the necessary kind of treatment that will render them hygienic to handle, the amount of dusting, scouring, and disinfecting that takes place depending upon the original condition of the rags.

2. *Seaming, carbonizing, garnetting.* All cotton or other foreign fibers are then removed, either by skirting or seaming (if the article is a garment that has been lined and sewed with silk or cotton) or by carbonizing (if the material is a mixture of cotton and wool). Carbonizing consists of immersing the material in a bath containing sulphuric acid. If carbonizing is correctly done, the cotton in the material will be completely destroyed and the wool will remain uninjured. The wool residue is spoken of as "extracts."

The next process is called garnetting, and is done by a machine with a multitude of sharp wire teeth which pull and tear the cloth into shreds. Various kinds of machines, such as pickers, cards, etc., follow, but their purposes are identical: to separate into individual fibers those that were originally twisted and matted together in the rags.

Grades of reclaimed wool. To a certain extent this rough treatment injures all the wool fibers. They are likely to be broken and their scales are mutilated. We can readily see, however, that it is possible for reclaimed wool to be of very high quality. If the rags are tailor's clippings of materials made from virgin wool, or if they are rags from soft woolen knitted goods also made of virgin wool, the reclaimed fiber may be of higher grade than wool from diseased or inferior sheep. If, on the other hand, the fibers are reclaimed from heavily felted materials, or from rags of low quality which were themselves made from wool that had been reclaimed once or twice, then the wool will be very poor indeed. The fibers will be short, weak, and broken, with scales very much mutilated. The material into which it can be made, however, will contain no foreign fiber and can strictly be

called "all wool." We see, therefore, that the statement "every thread wool" does not necessarily indicate a high quality of cloth.

At one time the term *shoddy* was applied to all fabrics containing reclaimed wool. But as there is such variance between the grades of reclaimed wool, and as the term *shoddy* has often been used as an expression of disrespect, wool manufacturers are now using for this class of fiber the terms *remanufactured wool*, *reworked wool*, and *reclaimed wool*, which are more accurate.

A poor quality of reclaimed wool is difficult to handle in the manufacturing processes. The very lowest quality is called mungo, and there is an interesting story of the origin of the word.

"It is told that in the early days of the trade a keen, hard-fisted Yorkshire factory master in the rag region had set his spinner the very difficult task of trying to spin something which was little better than food for the furnace. The spinner, after several efforts, went to his master and told him it was impossible to get the stuff to hold together sufficiently to make it into threads. But the blunt old Yorkshireman would not hear of failure, and sent the spinner back to his work with the injunction, 'It mun go! It mun go!' ringing in his ears. Ever afterwards, it is said, the term *mungo* was used by the trade for this particular kind of stuff."[1]

Use of reclaimed wool. Reclaimed wool is used in larger quantities for woolen materials than for worsteds, as wool fibers for worsted yarns are combed, and reclaimed fibers do not satisfactorily submit to this process. Thus worsteds are often stronger than woolens. Reclaimed wool is not satisfactory for hand-spun yarns, and is consequently not found in hand-made tweeds and homespuns. A specified amount and grade of reclaimed wool was used for uniforms and blankets during the World War, however, and it probably enters into most of our common wool fabrics.

[1] Frank Ormerod, Wool, p. 155.

When reclaimed wool is used with virgin wool, the two classes of fiber are generally combined in the mixing or blending process. The percentage of each kind of wool to be used is always specified, and some manufacturers make no secret of these percentages. That there is a real place in the cloth world for this remanufactured fiber can readily be seen, for this fiber of warmth would be quite unattainable by a large number of people, to whom it is almost a necessity, if wool materials could be made only from the virgin fiber. The use of remanufactured wool increases the amount and decreases the cost of our wool fabrics. Then, too, as fashion demands such frequent changes in kinds of cloth, the *endurance* of such materials as *novelty* fabrics is not of first consideration. For cloths that are to be short-lived, remanufactured wool is an excellent substitute.

Price an indication of value in wool fabrics. In comparison with cotton, wool is a high-priced fiber. During the years of the World War, cotton increased from 7½ cents to 40 cents a pound, and wool in the grease from 30 cents to $1. In normal times the price of cotton has averaged around 12 cents, and of wool 30 cents, a pound. With the increase of population in the United States, and the consequent decrease in area of suitable country for sheep raising, more intensive and scientific methods of growing wool must take place, and it is probable that the price of this fiber will be sustained on a higher plane than heretofore. Consequently the cost of the raw material combines with the expensive processes of manufacture to make good wool fabrics relatively high-priced.

This brief study of wool production and manufacture shows us that it is possible for many kinds of deceptions to be practiced in the production of wool fabrics. The appearance of the finished cloth is not always an indication of its true worth, and a guaranty may be worded in such a way as to be value-

less. How, then, can one protect one's self against fraud when buying a new suit of clothes or a pair of woolen bed blankets? The layman must trust to the honesty of the manufacturer or the merchant of whom he makes his purchase. A reputable manufacturer will turn out honest goods, and a reliable merchant will buy from that kind of manufacturer. The price also is some guide. When, for no obvious reason, a very remarkable "bargain" is found among wool materials, perhaps the small price paid is, after all, more than the article is worth. The microscope will reveal foreign fibers among the wool and, to a certain extent, will disclose remanufactured wool. But microscopic examination of our new suit or coat is a slow and tedious process. It is safer to buy from reliable sources and pay a reasonable price if we expect real service from our wool garments.

QUESTIONS AND ASSIGNMENTS

1. Collect, mount, and describe five samples each of woolens and worsteds.

2. List names of wool materials found in the dress-goods department of a store. In what widths do they come? Are they folded with the right side or wrong side out? Why?

3. Take one new worsted or one new woolen cloth. Find out as much as possible about it. How was it introduced? When? By whom was it designed? By whom manufactured? What is its advertised value? its real value as tested by time?

4. Which of your garments contain wool? For which ones is wool the usual material? Why?

5. What are the special advantages of worsted suits for men and women? of woolen suits? Which is better for a person who sits a great deal? for sports' wear? Why?

6. By what two methods can you discover whether or not a material is all wool? Describe the tests.

7. Why is "every thread wool" not a guaranty of excellence? Upon what factors does the high quality of wool materials depend?

8. Why is wool especially suitable for outer garments? What is its disadvantage for underwear? How are wool materials used in household furnishings?

9. Locate on the map the principal sheep-producing areas of the world.

10. Are sheep raised in your state? What is the approximate number? For what purpose are they raised? Are they increasing or decreasing? Why?

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See page 369.

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CHAPTER XV

THE STORY OF SILK

Silk cloth the fabric of beauty. By far the most fascinating of the cloth stories is the one about "Queen Silk." Silk fabrics are the most beautiful of all, and they are now in common use in our wardrobes and among our house furnishings. It is but a few hundred years ago that silks were worn only by royalty, the common people not being allowed possession of this wonderful material. Even in the days of our grandmothers the ownership of a silk gown denoted a certain degree of wealth and social distinction. In many homes these old-fashioned gowns—they are usually wedding gowns—are still in a perfect state of preservation and are highly prized as heirlooms.

Use of silk. 1. *For clothing.* Today silk in some form is possessed and worn by everybody. It is made into almost every kind of garment for woman, from her outside wrap of heavy brocade or velvet to her suit or gown of taffeta, satin, or jersey, her beautiful silk sweater, and her dainty Milanese underwear. The principal material of her hats is often of silk, and the accessories of a woman's costume—gloves, neckwear, parasol, hand bag, fan, and handkerchief—are all found in this material. An entire silk wardrobe, at the present time, is not at all uncommon for women in ordinary walks of life.

Silk in some form is quite indispensable for an infant's dainty layette. The growing boy wears it in his bright ties, and the little girl possesses silk stockings and hair ribbons.

Men, who in temperate climates still cling to heavy woolen outer garments (which are probably sewed with silk), wear

silk ties and socks. Silk shirts are common, and in hot climates silk pongee suits for men are almost universally demanded.

2. *For house furnishings.* Silk is a much-used material for table scarfs, lamp shades, cushions, pillow covers, curtains, draperies, couch covers, and rugs. The cords of our telephone and electric light may be of silk, for one of its most important uses for a long time has been for insulating wires.

3. *For special purposes.* Silk cloth is much used for other purposes little known to the average person. Cartridge silk was used during the World War to hold the powder for big guns, as it was the best material found for the purpose. After the war closed, thousands of yards of cartridge silk were left to be converted into civilian uses. Parachute silk is another fabric for which there is a constant demand by our government.

Source of silk fiber. As we learned in a previous chapter, the silk fiber is taken from the cocoon, which is made by the silkworm for a house in which to go through the period of metamorphosis when he changes from an ugly green worm with imperfect eyes and a very busy mouth to a creamy white moth with highly developed eyes and no mouth. All our fine silks, and by far the largest part of all our silk cloths, are made by worms that have been domesticated, the rearing and caring for these worms—sericulture it is called—being an important industry in itself. It entails a great amount of tedious, disagreeable work, and, while silk fiber can be produced in the United States, when we know more about the raising and care of the silkworms we shall better understand why sericulture does not thrive here.

Life and habits of the silk maker. 1. *As a worm.* The silkworm, whose true name is *Bombyx mori*, is hatched from an egg no larger than a mustard seed. He is a tiny, wriggling worm covered with black hairs and, from the first, is quite

sensitive to his surroundings. He is born with a voracious appetite and must be fed often both day and night of the first few days of his life. As he is an incubator baby, as it were, his food must be prepared most carefully. It consists of the tender green mulberry leaves, from which he sucks the juice. These leaves must be fresh, chopped, free from

FEEDING THE SILKWORMS

moisture in the form of water, and given in the right amounts and at the right times. Underfeeding or overfeeding are both disastrous to young silkworms. The tiny worms are sensitive to sounds, odors, and uncleanliness. Any violent noise is liable to injure or kill them, as will strong odors. In the cocooneries, which are usually built in retired places away from noises, the attendants go around quietly in bare feet. They usually dress in white, and there can be no smoking about the place. The worms are kept on shelves in trays which must be cleaned frequently. To clean a tray of worms a piece of paper the size of the tray and filled with small

perforations is placed gently on top of the worms. Fresh food is sprinkled lightly over this paper, and the worms crawl up through the perforations and begin eating. When they are all on the upper paper, the lower one with its refuse is removed. The worm outgrows his skin four times before he attains his full size. Like that of the snake, his old skin

SILKWORM EATING

splits, and he crawls out of it adorned in an entirely new suit, which is much larger than his old one. This achievement, which seems to tire the worm considerably, he repeats every seven or eight days, and at these times of molting he is quiet and supersensitive.

When the worm is about a month old, this stage of his life is nearly ended. He has grown to be a well-developed, light-green caterpillar about two inches long, with six legs, no eyes, and two powerful jaws. He has never moved from the tray on the shelves where he was born, and during his lifetime he has consumed of mulberry leaves 30,000 times his

initial weight. To the average observer, eating would seem to be his only business in life, and it is said that the noise of eating in these cocooneries, when the worms are full-grown, is like the cutting of grass or the falling of a heavy rain.

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THE MAN-CHOSEN HOME FOR THE COCOONS

But the silkworm has been doing something more than eating and growing during his thirty days of life. He has been extracting from his food and storing up in his body, to use later, a substance which for centuries the scientists have tried in vain to produce. On either side of his long body, glands have developed which are now filled with a semiliquid fluid which is of little use to him in his present condition, but which he is to use soon for a most important purpose. He is ready to spin his cocoon, and it is from the substance in these glands that he does it.

2. *As a silk spinner.* As birds select a protected place for their nests, so the pampered silkworm tries to select a safe place for his home. He becomes less intent upon eating and waves his head restlessly to and fro as if trying to find a new home. His ever-ready attendants quickly supply him with what he is seeking, by placing him in a bunch of many-branched twigs or grasses, and he soon settles down to work. From two tiny holes just below his mouth he begins to eject

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THROWING OUT THE GUY-LINES

the substance that he has been storing in these glands. Upon striking the air the two filaments immediately stick together and harden, making what we know as silk fiber. The worm first throws this filament in different directions, firmly fastening it to all the neighboring sticks and twigs, making a sort of nest, in the center of which he is to hide himself away in his cocoon. He spins the silk at the rate of from 9 to 12 inches per minute, and in a few hours his nest is made. Without stopping, for the strand is continuous, he then begins to throw the filament in a series of figure 8's up and down the length of his curled body, until he is entirely covered and hidden from view. It takes the silkworm about three days to make his cocoon, and at the end he has spun from 3000 to 4000 yards of filament. His silk glands are empty, he has become much reduced in size, and seems to be at the point of exhaustion.

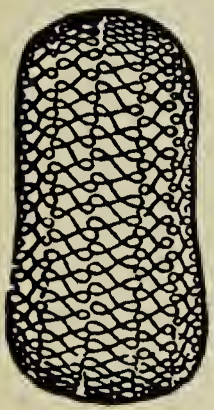
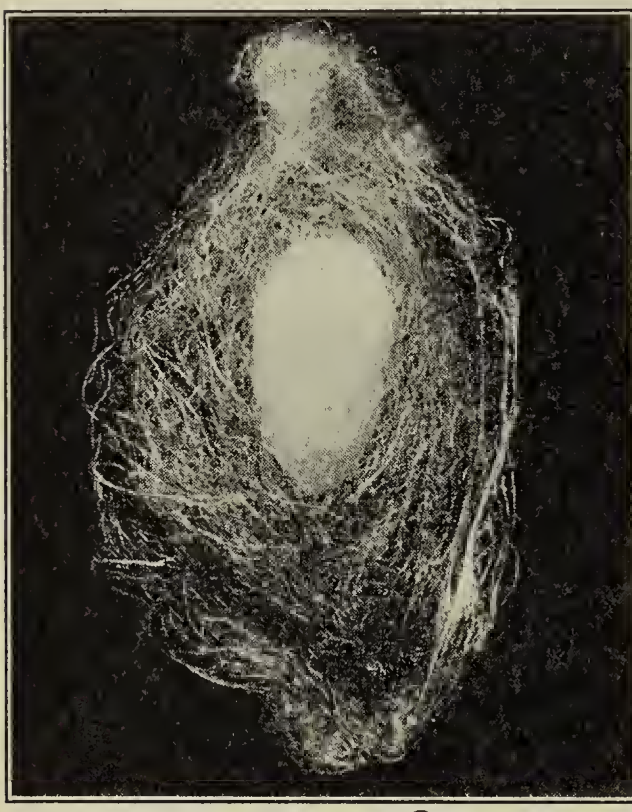


DIAGRAM OF STRUCTURE OF SILK COCOON

Courtesy Johnson, Cowdin and Company, Inc.

3. *As a pupa or chrysalis.* If we should cut open a cocoon a few days after the worm has finished spinning, we should find, not a soft, fat, green worm, but a small brown body about an inch long covered with a stiff, hard skin or shell. In this form he is called a pupa or chrysalis. This little pupa is fully alive, however, and will injure the long, unbroken

strand that he has made if he is allowed to wake up from his apparent sleep. So the cocoons are torn from their fastenings in the twigs and are subjected to either wet or dry heat until the chrysalises are killed. The cocoons can now be piled into baskets, bags, or boxes and put away for as long as one wishes or until these little yellow, green, white, or tan peanutlike bodies[1] are to be changed into the gorgeous silk fabrics that we find in our stores and homes.



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A COCOON IN ITS NEST OF FLOSS

Reeled silk. 1. *Reeling.* The unwinding of the little silken cocoons is a very delicate and skillful operation. It is called reeling and is generally done by young girls in the country where the cocoons are produced. The fiber is covered with a kind of gum which must be softened, and to do this the cocoons are soaked in warm water for a few minutes. The many broken fibers that fastened the cocoon in its nest are then removed with a brush until the end is found that begins to unwind the figure 8's of the cocoon. These tangled, broken, outside fibers are called floss and are used in another way. Usually the fibers of four or five cocoons are reeled together to make the strand that is spoken of as single, which

[1] Different-colored cocoons come from different countries. Those from Japan are usually white, from Italy yellow, and from France greenish. Wild cocoons are tan-colored.

is the form of the silk fiber before it is made into any kind of yarn. These four or more cocoons are floated in a pan of warm water, and the filaments are put together in a single strand and inserted into the eye of the reel or machine which is to unwind the cocoons and wind a skein of silk at the same time. These machines are sometimes run by hand or foot

REMOVING COCOONS FROM THE BUNCHES OF TWIGS

Courtesy of Cheney Brothers

power, but steam or electric power is rapidly becoming adopted. All the power-driven reels are called filatures.

This operation of reeling the silk from the cocoons sounds very simple, and at first one wonders why it is called delicate and skillful work. We have learned in connection with all the other fibers, however, that a high quality of cloth can be produced only from a high quality of fiber. These singles that are being reeled are the fibers that are made into silk yarns. Unless these long, continuous singles are smooth, strong, and uniform in size throughout, the yarns made from

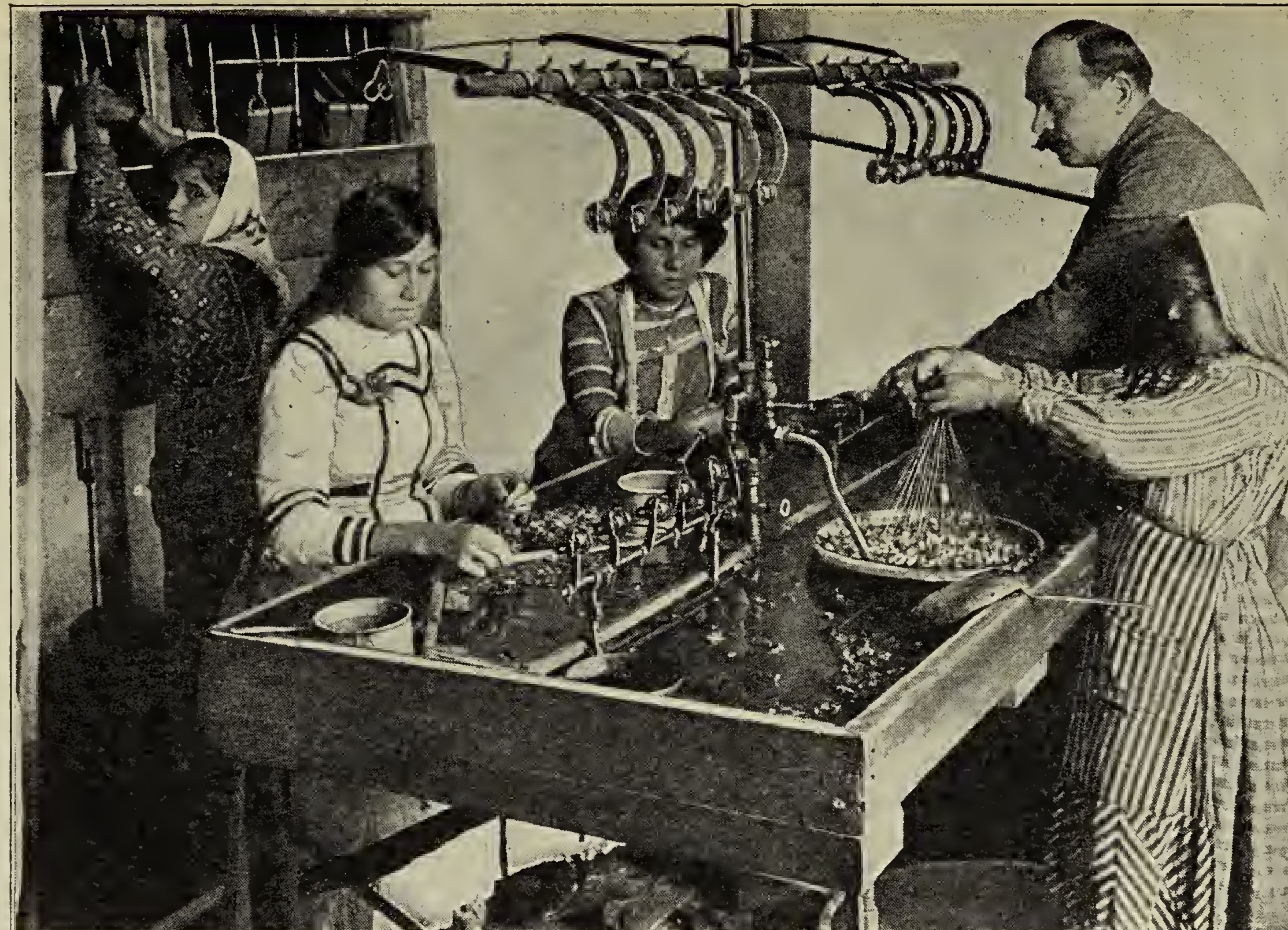
them will be imperfect and the material into which they are woven will not be of the highest quality. The fiber of no two worms is exactly alike in length or regularity of size, but the skein as it leaves the hands of the reeler should show no irregularities. With a keenness and a deftness almost incredible the eyes and fingers of silk reelers watch their strands, removing a fiber here where a strand has suddenly grown larger, adding a fiber there where there seems a weak place, starting the end of a new cocoon as an old one becomes exhausted, and making these connections so quickly and so perfectly that one who is watching can hardly follow the movements with his eyes.

The silk is reeled into skeins of varying sizes, which are packed into square blocks called books, weighing from five to ten pounds. This is now called raw silk, and it is usually shipped into this country in bales containing from one hundred to two hundred of these books.

2. *Throwing.* When the skeins of raw silk arrive at the mill, the singles are wound, stretched, doubled, and twisted to form the kind of yarn desired, this yarn being called reeled silk. These operations are called throwing, and the people performing them are spoken of as throwsters. There is neither carding, combing, drawing, nor spinning connected with the making of reeled silk yarns, but throwing is an important mechanical operation. The higher the quality of singles used, the better the grade of yarn that can be thrown, but in throwing, as in reeling, a constant vigilance must be maintained to insure an even run of yarn.

3. *Boiling off.* The gum called sericin still adheres to the reeled silk and can be removed by boiling in soapy water. This is called stripping or boiling off, and may take place in the yarn or the woven cloth.

4. *Organzine and tram.* There is generally more difference between the warp and the filling yarns of silk than between



REELING SILK

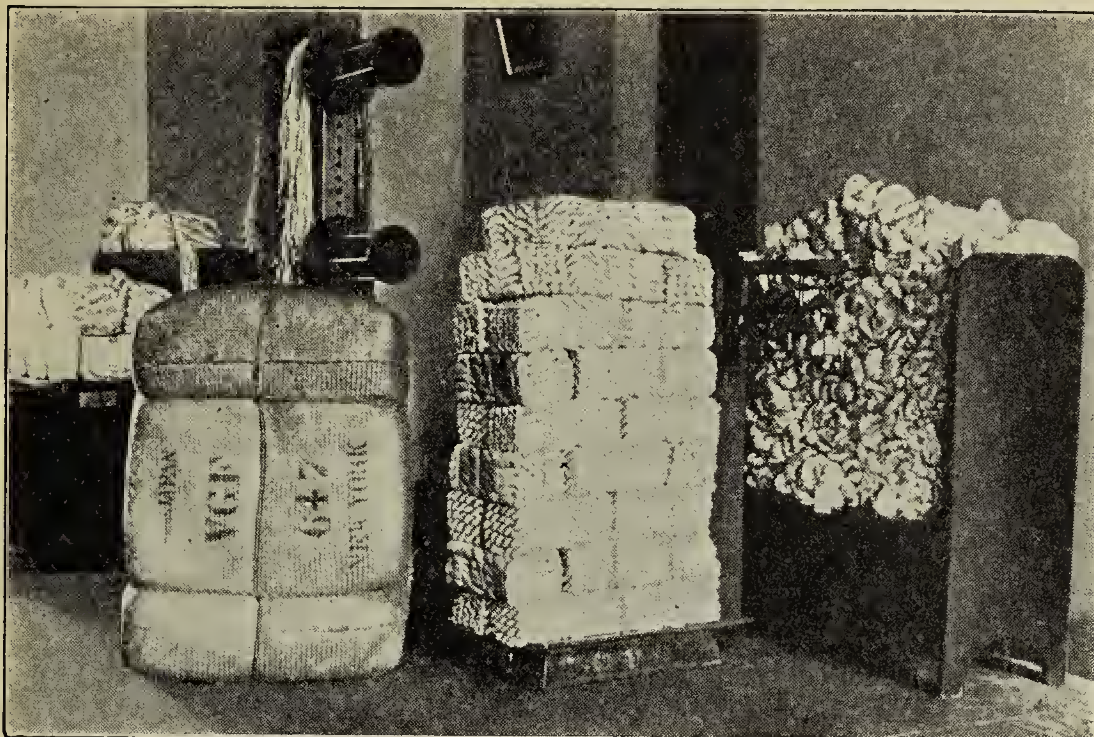
Note the delicate strands

those of any other fiber, and they bear different names. The warp is called organzine and is usually made of singles which are twisted in one direction but when doubled are twisted together in the opposite direction. This makes a hard yarn which is strong and even, though it may be exceedingly fine. The filling is called tram and is generally made of untwisted singles held together with only a slight twist.

Spun silk. The story of silk is not half told when we have described the making of reeled silk. In advertisements of hosiery we often see the expression "made of pure spun silk," and that seems to contradict our statement that silk is thrown and not spun. Both reeled silk and spun silk are correct expressions, however, and accurately describe the materials of which they speak.

1. *Source.* There is a large quantity of silk that consists of short or uneven fibers. The floss that is removed from the outside of the cocoons is of this character. The last few hundred yards of fiber that the worm spins are often weak and uneven, and there are many imperfect cocoons that cannot be reeled. There is also a certain amount of waste from the manufacturing processes. Before the invention of improved carding, drawing, and spinning machines these broken and irregular filaments could not be manufactured and were thrown away. Even at this time all the silk that cannot be reeled is classed as silk waste, but with our present high types of machines this waste is now converted into spun silk, a valuable addition to our silk materials.

Most of the broken fibers, however, come from what are called pierced cocoons. In describing the life of the silkworm we followed him to the chrysalid state, where he was killed by heat in order that man might obtain the uninjured cocoon. If, however, all the silkworms were killed in their cocoons, how would the silkworm industry continue? It is necessary for a large number of silkworms to be allowed



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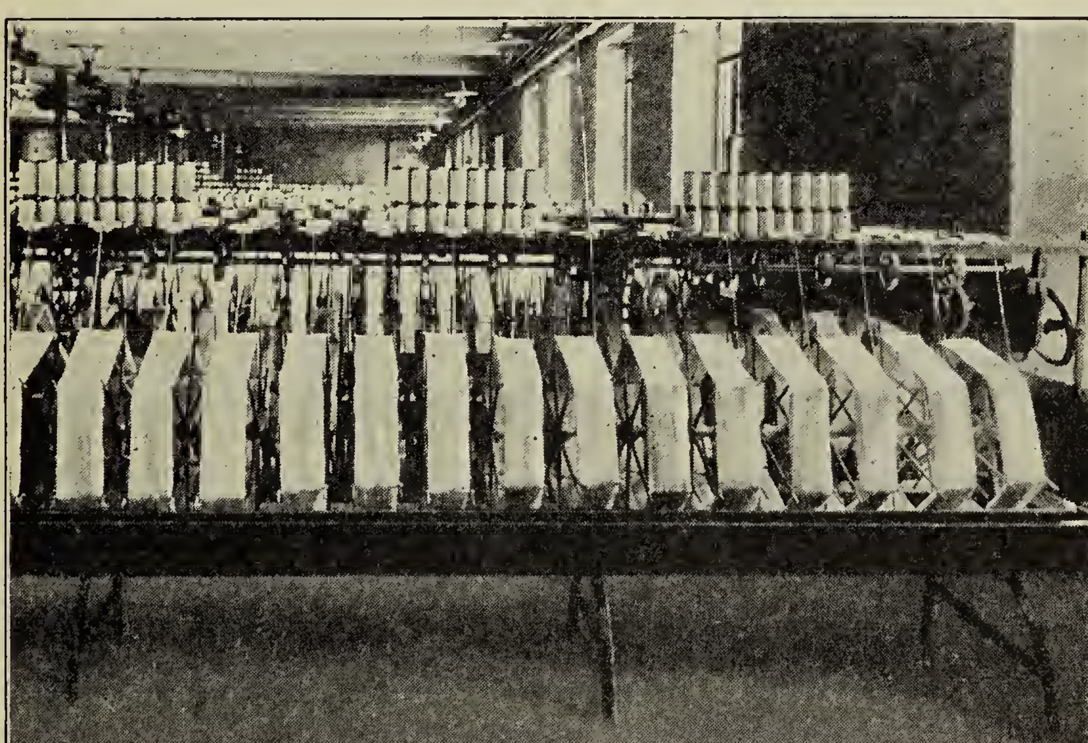
BALE, BOOKS, AND SKEINS OF SILK



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WINDING SILK

to live out their normal lives in order to reproduce, and it is while they are in the chrysalid stage that men choose between those worms that are to be kept for breeding and those that must die and give up their homes to be reeled. So a sufficient number of the best cocoons are selected for breeding purposes and put in a place favorable to the escape of the life that is inside. It takes about twenty days for the

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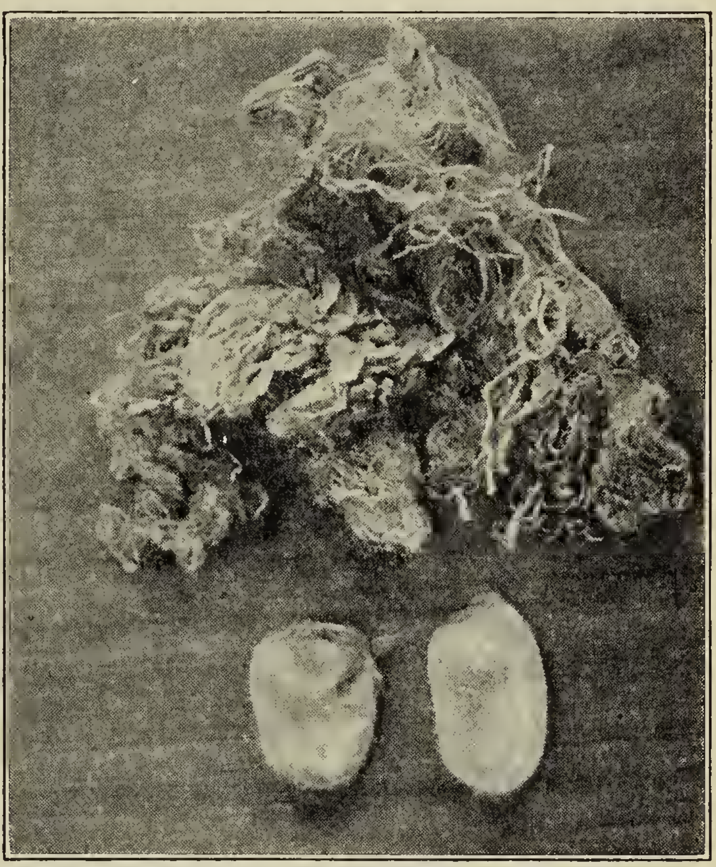
MOTHS EMERGING FROM COCOONS

chrysalis, or pupa, to prepare for the next form and work of the silkworm; at the end of that time he begins to eject a liquid which dissolves the fiber at one end of the cocoon. Then slowly out of this hole emerges, not a worm, nor the hard, brown chrysalis, but a sturdy, cream-colored moth. After drying his wings and resting for a few hours, he seeks his mate and they live together for the remaining period of their lives. During this time neither moth eats (they have no mouths) and they seldom move about at all. In about twenty-four hours after leaving the cocoon the male moth dies, and the female lives only long enough to deposit her eggs, when she too dies. The real purpose for which they were created—

the reproduction of their kind—has been accomplished and there is no further work in the world for them to do.

2. *Manufacture.* From these pierced cocoons out of which the moths have emerged, together with all the other kinds of silk waste, is made the spun silk of the trade. These fibers cannot be thrown, but must be carded, combed, drawn, and spun, as is the case with all the other fibers of short or irregular length used in the textile industry. Silk waste is usually brought to this country with the gum on. At the factory, after opening and sorting, the waste is boiled off, washed, and dried, as is done with reeled silk. It is then loosened, beaten, and opened up to separate the fibers and free them from the shells of the pupa and any other foreign matter that may have clung to them. The fibers are then carded and combed, or "dressed"; this process separates the mass into long, straight fibers and short, tangled ones, as is the case with wool. The long fibers, which are called laps, are then drawn, spun (usually on a mule), and woven into all kinds of fabrics. The short, tangled fibers are called noils, and are used for the cheapest kinds of silk materials.



SILK WASTE IN THE GUM—THE SOURCE OF SPUN SILK

3. *Grades.* The quality of yarn made from spun silk, and therefore the quality of the finished cloth, depends upon the kind of waste used. The yarn that has just been described, made from the laps of raw silk, would be of high quality, ranking well with reeled silk; but the noils, or short, tangled fibers, are reworked, the silk waste from the manufacturing process is reworked, and the shoddy picked from silk rags is reworked. As this conglomerate mass is constantly being reduced in quality with each grading for manufacture, we can begin to see how there may be spun-silk stockings of high quality, ranging from $3 to $9 per pair, or those of low quality that may sell for around $1 per pair. The term *spun silk* does not indicate quality; it only shows that the yarn has been made of the shorter silk fibers.

4. *Uses.* Spun silk is used for knitted goods, hosiery, pile fabrics, knitting and embroidery silks, trimmings, the less expensive grades of ribbons, broad silks, and upholstery fabrics, and, in combination with other fibers, for cloths that are mixtures. The silk used for insulation purposes is made from low-grade waste. New England is the center of the spun-silk industry, and much material of very high quality is turned out there each year.

Wild silks. There is still another class of silk materials to which we have not yet referred. They are the pongees, rajahs, Shantungs, tussahs, etc. These cloths differ from the majority of silks by being less lustrous, almost rough or harsh to the touch, and are often made of irregular yarns. Pongee is most frequently found in its natural color—unbleached. All the silks named are usually enduring, and natural-colored pongee "wears like iron." The fiber for these silks is made by a wild silkworm, who seems to impart to his product some of his own vigor. He eats what he can find,—usually oak leaves; hence the creamy or brownish color of the silk. He makes his cocoons where he pleases, and the

natives have to climb high trees to get them. He reproduces several times a year, while the domesticated silkworm reproduces only once a year, the eggs being kept in cold storage for months. The fiber he spins has many irregularities, and the worm does not seem to be fastidious about the manner in which he builds it into his cocoon, so it is often difficult to reel wild silk. If, however, the wild silkworm does not give the world of silk a refined product, he contributes to it a very useful material, and does this with little assistance from man. Wild silk comes mostly from India and the interior of China.

Natural endurance of silk fiber. Perhaps questions like these have come to every one of us before this: "Why is it that before my umbrella was six months old the silk in it cracked?" "Why did the silk curtains at my windows fall to pieces in less than a year?" "What made my taffeta dress begin to break or split in two or three weeks?" "How could I wear a hole in my silk stocking in one day?" It is true that silk is our strongest textile fiber and one of the most enduring. One of the New England silk mills was burned early in its history. Thirty years afterwards, when an excavation was being made near the scene of the fire, wound bobbins of silk were dug up. Upon examination the silk was found to be in a perfect state of preservation. The silk gowns "over a hundred years old" that we may have in our homes or see on display occasionally are without a break. Why does not silk "live" that way at the present time? Herein lies a secret of silk manufacture that is no longer kept a secret.

Reasons for loading silk. Silk, as we know, absorbs moisture very easily, and it also has the power to take up and retain substances that are dissolved in the water it absorbs. Silk is an expensive fiber, costing in 1921 from $4 to $6 per pound with the gum on. During the World War raw silk rose to $18 per pound. In boiling off, the silk loses from twenty

to twenty-five per cent of its weight. This loss greatly increases the cost of silk, for, instead of getting a pound for $6, the manufacturer has obtained only about three quarters of a pound. For many years it was considered legitimate and practical for the manufacturer to make up that twenty-five per cent loss by allowing the silk to absorb that amount in weight of some substance during the manufacturing process. There are many kinds of chemicals that can be used for this purpose, but it has been found that salts of metals—tin, lead, iron, zinc, etc.—will produce the most satisfactory results. The process of increasing the weight of silk in this way is called loading, weighting, or dynamiting, and when only the loss in weight caused by the removal of the gum is made up by loading, there follows no bad effect upon the silk. The public, however, is constantly clamoring for lower-priced silks, and the nature of the silk fiber allows this request to be granted so easily that silk manufacturers have yielded to the insistent demand, until now our stores contain quantities of low-priced silks which have the appearance of good silk but which may contain more iron or tin than silk.

Effect on silk of excess loading. When silk is dyed it can be soaked in these mineral solutions over and over again until it has absorbed once, twice, three times, and it is possible for it to absorb even seven times, its own weight in metal. Salts of iron are generally used for dark-colored silks, and salts ot tin for light colors. These metals may not affect the softness, luster, nor color of the silk, but the wearing or even the keeping of the material—whether it be on the shelves of the store, rolled up in our umbrella case, or hanging from a peg in our closet—will show how much they have affected the strength and endurance of the silk fiber. It is desirable, therefore, that heavily weighted silk be sold and worn rather quickly after manufacture. Sunlight will cause heavily weighted silk to rot and fall apart, as silk curtains and silk trimmings on

hats frequently prove. The combination of salt with the minerals used in weighting is disastrous to the silk fabric, as is shown by the action of perspiration on stockings and garments that touch the body. Tear spots will sometimes rot away the silk, and silks with excess loading last only a short time at the seashore.

Guides in buying silk. How, then, can we know whether or not the silk we buy, either in the piece or in the garment, will be satisfactory? We can never be absolutely sure of the silk material we buy, but there are some guides that may assist us in our selections. If a person wishes the article for other purposes than endurance, the question of whether or not the silk is heavily weighted need not be considered. In fact, the increase of exquisite fabrics that can be bought for a small amount of money compared with the prices our grandmothers had to pay for silk has added to the pleasure of thousands of people who can spend little money for beautiful things. But for economy or endurance the question of weighting is a vexing one. Silk made by manufacturers having a reputation for honest goods is generally dependable, as the reputable manufacturer stands behind his goods. The same principle should hold true of the stores and salespeople where silk is sold. Silks marked "Pure Dye" are not weighted. Limp, pliable silks, like crêpe de chine and georgette, are less likely to be weighted than stiff silks. Wash silks are not usually weighted. A soft satin is likely to wear better than a stiff taffeta. A high-priced silk *should* wear better than a low-priced silk, though this does not always hold true.

A very simple and practical test for weighting in silk materials is the burning test. Silk, being an animal fiber, bubbles and burns much like hair, wool, or feathers. A piece of silk material having no excess loading will lose its form and become almost entirely consumed in burning. But try to burn

a piece of heavily loaded silk and see what happens! The material gets hot, glows, and becomes brittle, but often the form remains entirely unchanged. In some silks the picks and ends can be counted almost as easily after burning as before. In fact, silks are sometimes so heavily weighted that they are almost fireproof. The loading, as well as the dyeing, may take place in the yarn or in the cloth, and frequently when a cloth is burned one set of yarns will be entirely consumed while the other set retains its form. It is this excess loading that causes the difference between the endurance of our grandmothers' silk dresses and our own. It is also one reason for the difference in price. The Chinese, we are told, were the first ones to discover the trick of making silk absorb metals, and that nation has practiced loading for many years. It is only within the last half century that loading has been employed to any great extent in America. China brought her silk trade into disrepute through excessive weighting, and there are manufacturers and stores in this country that have suffered loss of reputation in the same way.

Early history of silk. 1. *In Asia.* The story of the discovery of silk is full of mystery and romance. Legend claims that Si Ling Chi, a little fourteen-year-old Chinese empress, was the first person to observe the work of the caterpillars so numerous in her country, and to experiment with the threads they spun. This was away back in 2700 B.C. It is said that Si Ling Chi not only wove this fiber into cloth herself but started the silk industry in China. Whether or not this legend is true, it is a fact that the Chinese produced silk cloth nearly two thousand years before any other country knew of what the beautiful fabric was made, and even at the present time China observes a certain day each year in honor of the "Goddess of Silkworms." China guards her secrets well, and the secret of silk culture was no exception. She exported much silk material, but her people were

forbidden, under pain of death, to carry the silkworm in any stage of its life out of the country.

It is believed that Japan is the second oldest country in silk production, the secret having been learned from some Chinese girls who were carried to Japan. But this was as late as 200 or 300 B.C. India ranks third in possession of the secret, a Chinese bride having taken to her new home in India some silkworm eggs concealed in her headdress.

2. *In Europe.* Not until the knowledge of silk culture was made known to the Roman emperor Justinian did the secret have an opportunity to become at all accessible to the nations in Europe. Before that time silken fabrics had been imported from China and India by the wealthy people of the Roman Empire by caravans through Persia—a long and dangerous journey. When Justinian made war with Persia, the silk could no longer be imported, and he cast about for means of producing it in his own country. It is claimed that he hired two monks to make a pilgrimage to China and get for him the information that would allow him to start the industry. They returned, bringing back to him eggs of the silkworm hidden in their hollow bamboo staffs. This was in 555 A.D., and until his death Justinian held a monopoly of the silk industry. The secret had been liberated from China, however, and since that time Europe has experimented with silk production.

Sericulture in the United States. The raising of silkworms was started in some of the American colonies as early as 1620, and in 1759 Georgia produced 10,000 pounds of silk cocoons. Silk culture did not prove a profitable enterprise at that time, however, and soon died out. Between 1835 and 1849 the movement in the United States was again started, this time in New England, and its termination was attended by disastrous results. It was found that a certain species of mulberry tree upon which silkworms thrive would grow very

rapidly in America. A boom in mulberry trees sprang up, and in five years these plants increased in price from $4 per hundred to $5 apiece; but it was soon discovered that the raising of silkworms was a very tedious operation, demanding much more time and care than had been supposed. The mulberry trees, too, were not as hardy as they promised to be, and the people who had plunged into the enterprise began to lose their enthusiasm. About ten years after the beginning of the boom a blight killed nearly all the mulberry trees, causing hundreds of people who had joined the undertaking to lose all the money they had invested. The silkworm industry in that part of the country, therefore, was abandoned.

The United States is constantly experimenting with the production of plants and animals not native to this country. It has experimented with the raising of silkworms until there is no doubt that they can be raised successfully in many of our states. California at the present time is devoting considerable attention to sericulture, and certain states in the South are working on the problem. The price of silk, however, is based to a great extent upon the cost of the labor involved in its production, and the brief story given in this chapter shows the drudgery required to raise silkworms. Americans are fond of having machines do their work, and there are no machines adequate for the tending of the silkworms or the reeling of the cocoons. In the Asiatic and southern European countries the peasants—men, women, and children—work long hours for a few pennies a day. As long as silk can be produced under these conditions, it will not be possible for American silk to become a competitor in price with that of our Eastern and Western neighbors.

Silk manufacture in the United States. The United States ranks first in the manufacture of silks, the silk industry being concentrated in the eastern part of the country.

Connecticut ranks first in spun-silk products, and New Jersey in reeled silk. As we import most of our raw silk from China and Japan, the fiber makes a very long journey before it reaches the factory. Because silk is so valuable and so impossible of identification, it is a most attractive booty for thieves, and great precautions against robbery have to be taken in its transportation. When a ship containing a cargo of silk arrives at one of our Pacific ports, the silk is unloaded immediately, regardless of the time of day or night. It is taken off simultaneously with the mail and is at once loaded onto express cars waiting at the dock. The bales of silk in a single car are sometimes worth $125,000, and the value of the entire trainload may run as high as $4,000,000. It is heavily insured, the insurance rate on silk being excessively high. The trains that carry the silk across the continent are called silk specials and are always given the right of way, even passenger trains being sidetracked to let them pass. They are closely guarded and make no stops except to change engines during the entire journey. In spite of all these precautions, however, glaringly bold silk robberies are being committed constantly. A writer[1] in a popular magazine states the yearly loss of silk through burglary, while in storehouse or in transit,

UNLOADING SILK FROM AN OCEAN LINER

Courtesy of Port of Seattle

[1] Edward H. Smith, in *Saturday Evening Post*, June 26, 1920.

as being around $5,000,000. For this reason, as well as because of the expense of shipping the raw silk across the country and then shipping the manufactured product back, there is much discussion of the possibility of silk factories on the Pacific coast. Raw silk enters this country from the Orient through Seattle and San Francisco, and there would be a great saving of time and expense if silk could be manufactured in those cities.

Variety of silk combinations. Because of its many superlative characteristics silk is used in an almost numberless variety of ways and cloths. Even the materials made entirely of silk differ in character as well as quality of fiber. In some goods all reeled silk is used; our very best sewing silk, twist, ribbons, and broad silks are made of reeled silk. In some, all spun silk is used; excellent fabrics and fair spool silk are made from a high grade of spun silk. By far the largest amount of silk goods, however, is made of a combination of reeled and spun silk, reeled silk generally being used for the warp and spun silk for the filling. Many silks are woven in the gum, which is afterwards boiled off from the cloth. This is true of thin fabrics like georgette, chiffon, marquisette, and many of the crêpes. For some fabrics the gum is only partially removed. The material is then stiffer and is called souple silk. Sometimes the silk is left in the gum, as in the metalline so popular for trimmings and decorative purposes.

Silk mixtures. Silk is often used with other fibers in mixtures. Many of our plain lining satins have cotton backs and silk faces. Of our cotton-backed velvets the same thing is true. Seco, blossom, and ABC silk have one set of yarns of cotton. In our plated hosiery a cotton yarn is behind a silk yarn in every stitch. Some materials (charmeuse is one) sometimes have a wool back with a silk face, and there

are many combinations of silk and wool flannels and knitted goods. In many of these instances the cost of the materials or garments has been decreased, and the value, for its purpose, increased by such a combination of fibers. This is especially true of silk materials having a heavy cord running either way of the goods, as poplin, bengaline, and other ribbed or corded silks. The cord is frequently of cotton, though it may be of wool or of linen, entirely covered by silk yarns running at right angles to it. Silk may be combined with other fibers simply for decorative purposes, as in our silk striped, dotted, and figured voiles, ginghams, muslins, linings, and drapery materials. Silk stripes, lines, or dots in men's suiting and silk in wool dress goods give an added beauty to the materials. A great variety of fabrics for decorative purposes are made by the combination of worm silk with artificial silk, the metalline before mentioned being such a combination.

Silk not only lends itself to all kinds of weaves and gives beauty to a great variety of mixtures, but of all the natural raw materials it is the most susceptible to color treatment. It may be dyed in the gum or at any of the boiled-off stages, responding perfectly to any color. All methods of coloring are used with silk, whether dipping, stamping by the hand block, or coloring by the resist, discharge, or direct printing process. Silk is the most perfect material for batik coloring.

Queen Silk. This brief story of silk cloth will perhaps show that the superlative characteristics of the silk fiber justify the name *Queen Silk*, by which silk materials are often called. Our appreciation of the silks in our possession may be still further increased when we read the following statement made by one of our American writers on textiles:[1]

[1] Paul H. Nystrom, Textiles, p. 200.

It has been said that it takes more human labor to produce a lady's silk dress, from the mulberry leaves into the finished product ready for wear, than it takes to produce and build a locomotive out of the raw ores in the ground. More hours are expended and more people have something to do with the work.

QUESTIONS AND ASSIGNMENTS

1. Mount and describe ten samples of silk.

2. What is the most common weave in silk? Why? Name three silks of plain weave.

3. In what widths does ribbon come? How are the widths marked?

4. What is meant by "broad silks"? What is their usual width?

5. Compare a pair of silk stockings with a pair of wool and a pair of cotton stockings of the same relative grade. Give the characteristics of each pair, naming its advantages and disadvantages.

6. Where only one set of yarns in a piece of silk is weighted, which set should you expect it to be? Test by burning to prove the correctness of your judgment.

7. What is double-faced ribbon? shot silk? cotton-backed or wool-backed satin? Jacquard silk? ciré ribbon? duvetyn?

8. Name three corded silks; three heavy silks; three sheer silks; three lining satins; three silk-pile fabrics; three shirting materials; three underwear materials; three blouse materials.

9. What articles in your own wardrobe are made wholly or partly of silk? In what ways is silk used in your home?

10. For what purposes are low-priced, heavily weighted silks practical? For what purposes is it economy to buy only high-grade, pure-dye materials?

11. What new kinds of silks have been introduced this year? By what firms are they made?

12. Name three well-known silk manufacturers. Where are their factories located?

13. How should you wash a white georgette blouse?

14. Silk stockings will last longer if washed each time after wearing. Why is this so?

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See page 369.

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CHAPTER XVI

OTHER MATERIALS OF WHICH CLOTH IS MADE

I. ANIMAL FIBERS

1. Mohair

Characteristics of mohair cloth. We are by this time somewhat familiar with fabrics made from the cotton, flax, wool, and silk fibers. Among all these materials we have found none that looked and felt like this piece of white mohair. This cloth is smooth and lustrous, but feels wiry and stiff. By examining the warp yarns we discover that they are of cotton, while the filling yarns seem to be made of a stiff, wiry wool. As we pick out one of these wool-like fibers we find that it is coarser, longer, less curly, and more lustrous than any of the wool fibers from the woolens or worsteds that we have studied. This fiber is called mohair, and by this name the cloth is known. It is grown by the Angora goat instead of by the sheep, and as the goat has many characteristics in common with the sheep, so the goat fiber has many characteristics in common with the wool fiber.

History and habits of the Angora goat. The Angora goat is a comparatively recent addition to the fiber-bearing animals of the United States. Its original home was in Asia Minor, the first goats in this country having been imported from there in 1849. Turkey still produces the finest mohair grown. Like sheep, goats love the range, and these two animals will thrive in the same localities. Goats like to browse in brush, however, and are of great assistance to the farmer

in clearing newly opened-up brush land and getting it ready for cultivation. For this reason they are frequently found in small flocks where sheep could not subsist. Angora goats are raised in New Mexico, Arizona, California, and Oregon, and small numbers are found in almost all the other states; but Texas produces approximately two thirds of the entire number raised in this country.

KING TUT, RAISED BY U. S. GRANT, DALLAS, OREGON

The twenty-four months' fleece when sheared measured twenty-six inches and weighed twenty-one and one-fourth pounds. (Courtesy of *Angora Journal*, Portland, Oregon)

Fleece of the Angora goat. The Angora goat is an animal considerably smaller than a sheep and is covered with long, curly locks of hair. In the cooler climates, like Oregon, he is shorn once a year, the length of staple being from 8 to 10 inches and the weight of the fleece about 4½ pounds. In Texas, Arizona, and the other goat-raising states of the Southwest shearing is done twice a year, the six months' growth of staple being between 5 and 6 inches in length.

As in the case of sheep production, breeders are constantly trying to improve the quality of the goat fleece. There are always some coarse, stiff hairs, called kemp, mixed with the other fibers, and these hairs will neither take dye well nor yield themselves satisfactorily to the processes of manufacture. They must be taken out of the fleece, and their removal entails much time, labor, and expense. Angora-goat breeders are endeavoring to produce fleeces containing little or no

kemp. The length, strength, color, and luster of fiber are also desired characteristics. There are goats on record that have produced mohair over 20 inches long, the entire fleece weighing over 18 pounds. For average quality and length of mohair the price is usually from 40 cents to 70 cents a pound, but for the unusually long fleeces there is almost no limit to the value. At the Pan-Pacific Exposition in 1915 the fleece of Dodo, a prize goat exhibited there, hung 25 inches below his feet and weighed 30 pounds. It sold for nearly $400.

Uses of mohair, or Angora wool. Under the microscope the goat fiber shows almost no overlapping scales on its surface. For this reason mohair or Angora wool does not felt easily, and it shrinks much less than sheep's wool. Its hard, smooth surface gives little opportunity for dust to cling to it, and garments made of mohair remain clean a relatively long time. Angora wool is used for such materials as mohair, brilliantine, Sicilian cloth, and Palm Beach cloth, which are made into suits, dresses, coats, linings, and automobile tops. It is manufactured into braids and trimmings. It is used for knitting yarns for sweaters, scarfs, caps, socks, mittens, and babies' hoods. The most expensive brushed-wool sets for sports wear are usually made of Angora wool. The soft, furry hoods for infants, and the gloves and mittens for children, commonly worn in the colder parts of our country, are knitted from Angora yarn and are very attractive. Someone has made this little jingle that humorously describes the appearance of these articles:

> Mary had a pair of mittens
> That her mother knit for her,
> And they looked so much like kittens
> You could almost hear them purr.

The smooth characteristic of the fiber causes mohair to be a good material for pile fabrics. You may be surprised to learn

that all the plush used for the seats and cushions in the steam and electric cars and in the luxuriously furnished boats, and for the plush furniture which was so fashionable in the childhood days of our parents (and is still to be found), was made from the hair of the Angora goat. The curly, shaggy white "fur" used for children's muffs, neckpieces, and coat trimmings is usually from the pelt of the Angora kid, and much of the imitation Astrakhan and other textile furs are manufactured from mohair. Another important use of this fiber is the making of wigs for dolls, and we are told that many sedate women wear switches made from the choice long hairs of the sportive goat.

Limitations of Angora-goat products. The stiffness and smoothness of the mohair fiber, however, prevent it from conforming to the many uses of the wool fiber. Cotton or some other fiber is always used for the warp in clothing fabrics, and even then mohair materials are stiff and somewhat harsh. When soft, clinging lines are in vogue, mohair and brilliantine have little place in the feminine wardrobe. Angora wool has a definite place among our textile raw materials, but there seems no prospect of its ever becoming a fiber of general use. This fact alone would operate against an extensive goat-raising industry in this country, but the influence of another factor also retards goat production. Like sheep, goats produce two materials for man—fiber and flesh. The demand for lamb and mutton is constantly on the increase, stimulating the increase of sheep production. The flesh of the goat, however, is not particularly liked as a food by the American people. Before the strict enforcement of the pure-food laws, goat's meat was frequently sold as mutton, and the customer did not detect the difference. But now that it must be labeled and sold as goat's meat, there is an aversion to it which is hard to overcome. In the goat-raising

states the flesh of the kids is often barbecued, and those who have eaten this meat say it is most delicious. With more enlightenment as to its real nutritive value and more education in its preparation and cooking, goat's meat ought to become a very palatable addition to our meat supply. When this time arrives, goat raising will doubtless receive a much-desired stimulus.

2. Alpaca

While the Angora goat is the most important of the animals producing a wool-like fiber, there are a number of other goats or goatlike animals that bear a fleece which can be used in making cloth. The alpaca is such an animal, and his name has been given to a kind of cloth which was originally made from this fiber.

The alpaca goat. The alpaca goat is a small animal whose home is in Peru, high up among the Andes Mountains. He is dark, frequently black in color, and his fleece averages over 6 inches in length. He is raised in small herds by the Indians of that country and is usually shorn twice a year. From Peru the alpaca wool in its raw state is shipped to England, where it is manufactured into yarn or cloth.

Characteristics of alpaca wool. Like Angora wool, alpaca wool is a long, lustrous, somewhat stiff fiber containing kemp, —hairs that do not conform to the manufacturing processes. After proper treatments, however, alpaca wool is manufactured into beautiful yarns and fabrics. It is used for substantially the same purposes as Angora wool, being particularly popular for knitted sports garments. Brushing enhances the beauty of alpaca materials, as the long escaped ends of the fiber allow an increased area for the luster to be displayed. Garments made from alpaca wool are attractive in appearance and, if we know something of their history, are interest-

ing as well. An American manufacturer of alpaca knitted goods speaks thus of his materials:

> When you wear this alpaca-made article which you have purchased, remember that to produce it the raw material of which it is made has had to travel over ten thousand miles, and that from the time the lustrous alpaca wool is sheared until it reaches you in its finished form two years have elapsed, while the labor of three nations has been involved.

3. Vicuña

Another attractive material found in the stores occasionally is called vicuña. Vicuña wool grows on an animal bearing that name, and it is another of the small, goatlike animals found in the high Andes Mountains. Unlike the alpaca, however, the vicuña cannot be domesticated and must be shot in order to be deprived of his fleece. The fabric called vicuña is usually a very soft, light-weight, beautiful material and probably resembles the cloth formerly made from the vicuña's fine, silky fleece. It must be made wholly or in part, however, from some other kind of high-grade wool, as nearly all the vicuña wool now in the United States is kept for exhibition in museums and technical institutions.

4. Cashmere

Cashmere material, named from the little Cashmere goat that perhaps originally furnished the fiber for its manufacture, was a common fabric years ago. It was a fine, soft, light-weight wool material and was used for the "best dresses" of those days.

Home of the Cashmere goat. The Cashmere goat is one of the small, fiber-producing goats that live among the Himalaya Mountains of India and China. His fleece consists of two kinds of fiber, the under, or down, hair being unsurpassed

for softness and fineness. The long, coarse hair is of no commercial value. The amount of Cashmere wool that can be produced is exceedingly limited, however, as an entire fleece weighs only about half a pound. Another reason for its scarcity is that these goats are never sheared, the fiber being obtained from the live animals by frequent combings during the shedding season.

Uses of cashmere. This beautiful fiber can be found in the rare old India and Cashmere shawls and in some of the other fine, beautiful fabrics manufactured in and around the province of Cashmere. But when we buy cashmere stockings or cashmere piece goods at the store, we ought not to expect them to contain any of the fiber of this little animal. This particular name is given to materials containing fine, soft wool fibers, resembling in those respects the fiber of the Cashmere goat.

5. Camel's Hair

Limited supply. All cloth called camel's hair was originally made of the hair of the camel, as its name implies. Only the fine, soft hair which grows on certain parts of the camel's body is used in this way. As there are relatively few camels in the world compared with the leading fiber-bearing animals, there can be but a limited supply of this fiber in the market at any one time. There are fine knitted garments, sweaters, scarfs, etc. made entirely of camel's hair, and certain pieces of woven materials where camel's hair is used entirely or in part for the yarns. Such fabrics are exquisite in texture and command a distinctive price. Camel's hair is also much used in Oriental rugs. But *camel's hair* has now become a trade name, and the medium-priced materials called camel's hair probably contain very little, if any, of the coat of that strange beast of burden. These fabrics are usually fine, soft, and more or less napped and are made

from high-grade sheep's wool. They are manufactured into robes, blankets, coats, and dress goods.

Two kinds of fiber from the camel. Camels, like the many goats we have mentioned, produce two kinds of fiber. The soft wool hair is fine, strong, and tan in color. This is the fiber used in making the high-grade articles mentioned. The stiff, beardlike hairs of the camel also have a distinctive

CAMELS IN CHINA

use. They are long, strong, and enduring. They are the best material known for the manufacture of press cloth used in cottonseed-oil and linseed-oil presses.

Sources. The camel, long known as "The Ship of the Desert," is a native of the hot countries in Asia and Africa, where he is used as a means of transportation. In many of these countries the camels are not shorn, but their hair is collected by the natives as it falls out during the shedding season. Most of our camel's hair comes from China and Russia.

6. Horsehair

Horsehair cloth was, in the days of our forefathers, very fashionable as a covering for furniture. Is there anyone among us who has not had the fun, as a little child, of climbing up and slipping off grandmother's haircloth sofa? Haircloth was used, in those same days, in the bottom of women's skirts so that they would stand out stiff and full.

Haircloth is made with a strong cotton warp, and a separate hair is used for each pick of the filling. The hairs are selected from the manes and tails of horses in South America and are as nearly uniform in length and size as possible. Horsehair cloth is, therefore, as wide as the length of the individual hairs that make the filling. Horsehair braid is used at the present time for hats, and the cloth is used for the stiffening in men's and boys' suits.

II. VEGETABLE FIBERS

1. Ramie

Chinese linen, Canton linen, or grass cloth. The material in this handsome luncheon set seems entirely different from any cloth that we have handled before. It resembles linen in the irregularity of its yarns, and silk in its luster, but it has neither the leathery feel of linen nor the softness of silk. It is a stiff material with a glassy luster and an almost transparent whiteness. This is called Chinese linen, Canton linen, or grass cloth and is made of the bast fiber from the ramie plant, which grows abundantly in China and India. Ramie, which belongs to the nettle family, is a large and luxuriant plant growing to a height of from 5 to 8 feet, and the fibers taken from the stem are several feet long. They are very strong and lustrous and can be separated into extremely fine fibers, as is the case with flax.

Ramie fiber. Ramie is a beautiful and useful fiber, but the expense of decortication, or cleaning the fiber from its surrounding woody tissue, prevents it from becoming commercially profitable. Ramie will grow luxuriantly in the warmer parts of the United States, and there have been spasmodic attempts to encourage the production and use of ramie in this country.

A number of years ago a firm began the manufacture of mesh and knitted underwear of ramie fiber, and these garments were considered very practical and hygienic. The enterprise, however, did not continue to flourish and was given up after a few years. If there is ever found a method by which ramie fiber can be cleaned easily and economically, it may become one of our popular textile fibers. But with King Cotton at her very door, clamoring to be used, the United States has little desire to risk time and money in experimenting with a new fiber which requires an expensive step in its preparation.

Uses of Chinese linen. Ramie cloth, or Chinese linen, can be bleached a dazzling white, takes dye extremely well, is very strong and durable, and never loses its luster nor stiffness. The natives of China, of the Philippines, and of the other South Sea Islands wear it for clothing. In this country grass cloth is used mostly for doilies, luncheon sets, and artistic tablecloths.

2. Jute

Uses of burlap. In the South, where cotton is baled, in the Northwest and Southwest, where wool is baled, in the sections of the country where potatoes, beets, turnips, and other root vegetables are raised, in the sugar refineries, and in hundreds of other industries where the materials must be held in containers to be transported, we find tons and tons of sacks or bags of a coarse brown material being used for this

purpose. We call them gunny sacks, and the material of which they are made is known as burlap. They are not attractive in appearance, and we know they are not particularly durable, as the torn coverings of the cotton bales have shown us; but they make an inexpensive and, in most cases, a satisfactory wrapping for the purposes above mentioned. In our

RETTING JUTE IN INDIA

Courtesy of Bemis Brothers Bag Company

own homes or in the drapery section of any store we find cushions, couch covers, and hangings made of burlap which has been dyed or printed, and in this form it is much higher in price. Burlap is also used for the backs of carpets and rugs and for the foundation of linoleum and floor oilcloth. This same fiber is used, to a certain extent, in cheap cords and strings.

The jute plant. Burlap is made from jute, a plant from 13 to 14 feet high, which grows in great quantities in India.

It is a bast fiber, from 4 to 8 feet long, grown and cleaned in foreign countries and bought by the United States at a small price. Like all other bast fibers, jute must be separated from its woody covering. In the countries where it grows, the natives, who work for a few pennies a day, remain in the dirty water as they beat the bark from the fiber. Jute, like ramie, will grow in the warm sections of our own country, but until decortication can be reduced to a less expensive process than it is at the present time, the United States will probably continue to import her prepared jute from its native country.

3. Piña, or Pineapple Cloth

Another kind of cloth that is to be found in our Oriental shops is piña, or pineapple cloth. This is also a product of the islands in the East and is a favorite fabric among the women in the Philippines.

The pineapple fiber is taken from the leaves of the pineapple plant. It is straight, lustrous, and strong. The piña cloth made and worn by the natives is fine, stiff, almost transparent, and frequently dyed in bright colors according to the native taste. As the cloth is so thin and permanently stiff, it stands out from the body of the wearer, making a desirable material for hot climates. There are decided styles in these piña garments of the natives, and the fashioning and folding of this stiff material so that it shall give exactly the right lines to the costume is rather difficult for the foreigner to learn. In this country pineapple cloth is little used.

4. Hemp

Uses of hemp. Occasionally in our homes or in the stores we find rugs or carpeting made of hemp. In olden days the strips of carpet used on stairs and in the aisles of churches, private institutions, and public buildings were frequently of

hemp. Shoe thread is usually of linen, but during the World War, when flax was so scarce, much of the thread used in the manufacture of army shoes was made of hemp instead of flax. Hemp is also used for the warp of ingrain and Brussels carpets and for wrapping cord.

Kentucky hemp. There are two principal kinds of hemp: Kentucky hemp and Manila hemp. Kentucky hemp, which

HARVESTING KENTUCKY HEMP

Note the height of the plants. (Courtesy of the United States Department of Agriculture)

is grown in Kentucky, Wisconsin, California, North Dakota, and several of the central states, is the kind used for the purposes mentioned. It is a tall, woody plant, averaging from 6 to 9 feet in height, and produces a bast fiber of "great length, strength, pliability, and resistance to water and general wear."[1] The hemp fiber is obtained by decortication, and there are now throughout these hemp-producing states

[1] *Bulletin No. 293*, Wisconsin's Hemp Industry.

especially constructed and equipped mills for separating the fiber from the stalks. Wisconsin has nearly a dozen of these mills. Perhaps you are asking why the Americans go to the trouble of producing and preparing this bast fiber when linen, jute, and ramie, which are also bast fibers and also have to undergo decortication, are imported. One answer to the question is that before the World War large quantities of hemp were imported from Russia and Italy, but during the war period those sources of supply were entirely cut off. China is the home of this kind of hemp, but little is exported from there, and the same thing is true of Japan. Hemp will grow easily in the United States. As it is our most important fiber for wrapping cord, necessity became the mother of invention, and those war years brought forth machinery for harvesting and decorticating this much-needed fiber. The production of Kentucky hemp in the United States now seems assured. While our principal use of hemp at the present time is for wrapping cords, it is also somewhat used for ropes and binder twines. With an increased supply of the fiber, hemp will doubtless be used for nets, fish-lines, sewing thread, bagging and sacking of all kinds, and perhaps for rough and heavy fabrics for clothing and house furnishings.

Manila hemp. Manila hemp is the fiber from the leaf of a bananalike plant which grows in the Philippines. It is a lustrous, strong, and even fiber, varying in length from 6 to 12 feet. These straight, stiff fibers are not suitable for weaving, but can be twisted into the strongest kinds of cable. A "rope walk" is a straight, narrow building several hundred feet long, where these heavy ropes are stretched and twisted. Manila hemp is the best material known for hawsers, ships' cables, and other ropes to be used around fresh or salt water. It is also used for all sorts of ropes and cordage where strength and flexibility are required.

III. MINERAL FIBERS

Asbestos

The principal mineral fiber used for fabrics is asbestos. Asbestos is a fibrous rock found in many parts of the world, but most of that used in textile manufacture comes from Quebec, Canada.

Nature of fiber. Asbestos fiber is a stiff, white or gray, inelastic fiber, not at all suited to the general uses of cloth. It has one most important characteristic, however, which allows it to hold a unique and commanding position in the textile world. It is absolutely fireproof and acidproof. Because of this wonderful quality asbestos fabric is in great demand where protection against fire is important and where powerful acids are handled.

Uses of asbestos. Asbestos fabrics are found in our kitchens for holders, flatiron stands, table pads, and plates to use about the stove. Asbestos is a poor conductor of heat and is used as wrapping around our furnaces and hot pipes. Asbestos is used in the mechanical industries for aprons, belts, and gloves, and for acid filters in all sorts of chemical processes. It is used for roofs, floors, and walls in the construction of fireproof buildings. Most theaters in the United States are required to have an asbestos stage curtain. Asbestos can be spun into yarn and woven into cloth, or it can be pressed into a feltlike fabric. In its limited field asbestos is one of the most important textile fibers in the world.

IV. MANUFACTURED FIBERS

1. Paper

Paper fabrics for clothing. Paper yarns have been used in the manufacture of "fiber matting" carpets for some time, but it was not until the World War endangered the produc-

tion of so many natural textile fibers that paper was employed in the manufacture of light-weight fabrics to be used for clothing and household purposes. In Germany the manufacture of paper clothes for both her soldiers and her civilian population was undertaken, and some quite marvelous pieces of material were turned out, resembling to a remarkable degree fabrics made from natural fibers.

Characteristics of paper cloth. Paper cloth is not attractive. It is stiff and nonelastic and has a dull, dead appearance and feel. Necessity proved that it was possible to manufacture a material for covering the body if all our natural textile fibers became exhausted, but under ordinary conditions the only use for paper fabrics and paper garments in this country is as a curiosity and a proof of man's inventive genius.

2. Artificial Silk

A complete description of artificial silk is to be found in Chapter XVII, "Rayon, a Chemical Triumph."

QUESTIONS AND ASSIGNMENTS

1. Get samples of cloth made from each of the fibers named. Mount and describe. (Get imitations when the genuine article is not obtainable.)

2. Name garments or articles, used by your family, that are made from the following:

mohair	hemp	jute
horsehair	asbestos	ramie, or China grass

3. Are any of these fibers produced in your state?

4. Locate on a map each country mentioned in this chapter.

5. Write a paper showing the habits and customs of the people in the foreign country where one of these minor fibers is produced.

6. What current publication gives the best illustrated and most graphic description of these little-known countries?

7. Tell what writers give interesting information about each of the following countries:

India	Russia	Philippine Islands
China	Persia	South America

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See page 369.

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CHAPTER XVII

RAYON, A CHEMICAL TRIUMPH

Reason for the discovery of rayon. Rayon, our only man-made textile fiber, has now attained such an important place in the world of cloth that it is interesting to trace the incidents of its birth and early struggles for existence. This great contribution to our textile materials seems to have been wholly the result of man's desire to discover, to originate, to create something new, rather than that of an urge to fill a crying need. At the time when rayon was first conceived, there seemed no lack of the natural textile fibers to clothe the people of the world and care for all their textile wants. There was already wool and cotton for the clothing of the common people, linen for household needs, and silk, the fabric of beauty and luxury, for the nobility and the higher classes. The introduction of another fiber was unthought of and seemingly unnecessary.

Scientists are, however, always curious and eager to originate something entirely unknown before or to produce in another way something that already exists. As a result of this insatiable thirst on the part of chemists during the nineteenth century, rayon was discovered.

Réaumur's dream of a synthetic fiber. The history of rayon from its beginning to the present time comprises one of the most fascinating of all the cloth stories. Rayon had its birth as a fiber with commercial possibilities between 1880 and 1890 in a chemical laboratory in France. For years before this scientists had believed that it was possible to produce

chemically in the laboratory a material similar to that which the silkworm produced in his living organism. As far back as 1734 a Frenchman by the name of Réaumur made the statement that silk was only a liquid gum that had been dried, and there seemed no reason why silk gum could not be imitated as well as other varnishes. His experimentations,

SPRUCE FORESTS TO BE TRANSFORMED INTO SHIMMERING SILKS

Courtesy of Zellerbach Paper Company

however, and those of other chemists at that time succeeded no further than to convince scientists that his prophecy had possibilities, until 1845, when nitrocellulose was discovered by Schönbein. With the advent of this new chemical much experimentation began, and ten years later a Swiss by the name of Audemars of Lausanne took out a patent for transforming dissolved nitrocellulose into fine threads which he called artificial silk. From then on scientists in many of the European countries continued to experiment upon the production of a synthetic textile fiber, each one adding some-

thing to the small amount of knowledge already existent on the subject.

Production of a fiber that "resembles silk" by Chardonnet. There is one man, however, whose name will always be associated with this new fiber, for it was he who proved beyond all doubt that a new and practical chemical product had entered the world of textiles. His name was Count Hilaire de Chardonnet, a Frenchman, who was a purposeful and conscientious research worker in the field of chemistry, and who was for some time a pupil of the great French biochemist, Louis Pasteur. At that time Pasteur was studying the diseases of the silkworm, and this study gave Chardonnet an intimate knowledge of the way in which the silkworm produced the silk fiber. He saw how the worm transformed the mulberry leaves that he ate into a gum which he secreted in his body until he ejected it into the air through two tiny spinnerets in his head. He saw that the contact of this gum with the air caused it to harden permanently, leaving a strong, continuous fiber all ready for man to use.

Chardonnet knew the substance of this gum to be cellulose, which the worm extracted from the mulberry leaves he ate. With the knowledge obtained from those earlier experimenters and this more intimate knowledge of the worm's processes, he experimented with the production of cellulose and the forcing of it through tiny holes into threads, using for his raw material the limbs and trunks of the mulberry tree. In 1884 Chardonnet produced his first synthetic fiber. He could not duplicate in his laboratory what the silkworm produced in his living organism, but he had evolved a substance that had a similar appearance. This fiber he described as "an artificial textile material resembling silk."

First rayon factory. In 1889, five years later, Chardonnet exhibited a collection of specimens of his product. This exhibition made such an impression on the minds of far-seeing

capitalists that money was provided for the erection of a factory to manufacture this new textile material. Thus was built in 1889, at Besançon, Chardonnet's home town in northern France, the first artificial-silk factory in the world. This factory continued to operate successfully until 1914, when it was used by the French government for the manufacture of gun cotton. After the war the factory was bought by a large manufacturing company, who remodeled it and are still using it for the manufacture of rayon.

Growth of the rayon industry during the life of Chardonnet. Chardonnet lived until 1924. He saw the industry to which he had given birth grow beyond his wildest dreams, and during all his long life he watched and assisted in the development of this lusty child. He saw the manufacture of rayon grow from that first small factory built in France in 1889, producing only a few thousand pounds of yarn a year, to the establishment of many factories, located in practically every civilized country in the world, producing millions of pounds a year. He saw those first stiff, unwieldy fabrics that were made from the yarn he produced replaced by those whose beauty, variety, and practicability were unequaled by materials made with any other textile fiber. Is it any wonder that Count Hilaire de Chardonnet is called "the father of the artificial-silk industry"?

The search for other methods of producing rayon. As the advent of any new product which bears the earmarks of success always challenges other scientists to find a competing method of producing the same thing, so the appearance of this new textile fiber stimulated other chemists to a search for other ways of producing rayon. Chardonnet's work had proved that the basic material of this new fiber was cellulose, the substance that constitutes the essential part of the framework of all vegetable growth. It was with the treatment of cellulose, therefore, that these chemists experimented. They

searched for different processes by which a gelatinous mass of cellulose could be drawn out into threads which would harden permanently and remain indestructible in water. One scientist, therefore, secured the end sought by means of one chemical process, and another achieved a similar result in quite a different way. There have survived out of all this experimentation four different methods of treating cellulose chemically so that a practical textile fiber can be produced.

Four important processes now in use. 1. *The Chardonnet, or nitrocellulose, process.* The pioneer process used by Chardonnet was to convert cellulose, usually obtained from cotton linters, into gun cotton, or nitrocellulose. (Gun cotton is made by immersing cellulose in a mixture of nitric and sulphuric acid.) It was then dissolved in a mixture of alcohol and ether, filtered, and aged. This jellylike substance was then forced through tiny holes, or mechanical spinnerets, into filaments which hardened in the air through evaporation of the alcohol and ether. These tiny filaments were then grouped together into strands, which were wound on bobbins as rayon yarn. After drying, this yarn was denitrated with alkaline sulphides, bleached, washed, twisted, and reeled or skeined. Lehner, a Swiss chemist, shortly afterwards modified this method by coagulating the filaments in a water bath instead of allowing them to harden in the air. This method of making rayon is still being used and is called the Chardonnet, or nitrocellulose, process.

2. *The cuprammonium process.* The first one to introduce any important change in the process of making this new fiber was another Frenchman, Louis Henri Despaisses, in 1890, a year after Chardonnet had exhibited his new product. Despaisses achieved his end by dissolving cellulose in ammoniacal copper oxide, known as cuprammonium solution or Schweizer's reagent. This solution was then forced through tiny spinnerets, as in Chardonnet's method. The resulting

filaments were passed through a mixture of sulphuric acid and water, and then washed in acetic acid. The resulting fiber seemed to be very similar to that made by Chardonnet. This was called the cuprammonium process and is now much used in the "stretch spinning" process of yarn manufacture.

3. *The viscose process.* Another and important process was developed shortly afterwards, in 1892, by two English chemists, C. F. Cross and Edward J. Bevan. Through studying alkali cellulose and mercerizing reactions, they developed a method of treating cellulose with caustic soda, producing a jellylike substance which they called viscoid (alkali cellulose xanthate). This substance, forced through tiny holes into filaments as in the other processes and then treated with carbon bisulphide, produced a yarn comparable to that made by the other methods.

This was a simpler and much less expensive way of producing this new fiber. Its possibilities were immediately seen by interested capitalists, and a company was formed for its further development and the control of patents. With improvements and modifications the viscose process continued to grow and flourish. In 1929 about 80 per cent of the world's rayon was made by the viscose process.

4. *The cellulose-acetate process.* The fourth and—at the present time—latest process for making rayon is the cellulose-acetate process. The cellulose-acetate compound was known as far back as 1869, and experimented with by many scientists at that time. Nothing of any commercial value was produced from this substance, however, until after the World War, when it was found that a huge factory built at Spondon, England, for the purpose of making "dope" for dressing airplane wings was then to become useless. The "dope" manufactured was an acetone soluble cellulose acetate which had been perfected for use by Henri Dreyfus. Attention was turned to the conversion of this huge, well-equipped fac-

tory into a profitable peace-time plant, and the development of this new process of making rayon was the result.

Cellulose-acetate rayon has for its base cellulose, as is true of all the different kinds of rayon. In this case, however,

DIAGRAM SHOWING SPINNING OF SILK AND RAYON YARNS OF THE SAME SIZE

Courtesy of American Bemberg Corporation

the cellulose is treated with acetic anhydride, glacial acetic acid, and a substance that will unite these two different elements, usually sulphuric acid. It is precipitated in water, washed, filtered, and dried, after which it is dissolved in acetone, filtered, and stored in tanks, ready to be used when desired. It is spun by being forced into the warm air, where

the acetone is evaporated. The yarn thus produced differs materially from that made by any other process. Because of these special characteristics, the fabric, which is best known by its trade name *celanese*, requires a different kind of treatment in the dyeing and cleaning processes from that given to other rayons.

Advantages of each of the four processes. Each of these four processes of manufacture claims to have its special advantages. The Chardonnet, or nitrocellulose, process is somewhat expensive, as it uses cotton linters for its cellulose and requires rather high-priced chemicals. It produces a strong yarn, however, by means of a comparatively simple process.

The cuprammonium process uses mostly cotton linters and allows what is called the "stretch spinning" method. This means that large filaments are ejected into a spinning bath which partially coagulates them. They are then drawn or stretched into the required fineness. It is claimed that this method, which was perfected by a firm in Germany, produces a finer and stronger yarn than can be made in any other way. This yarn, which is especially adapted to women's hosiery, is now being made in the United States in considerable quantities.

The viscose process utilizes cheaper raw materials—pulp wood for the cellulose, and caustic soda, carbon bisulphide, and sulphuric acid for the principal chemicals. All these raw materials are relatively abundant and comparatively low in price. Viscose products are very satisfactory and are adaptable for both woven and knitted fabrics. Many producers use this process. The viscose is the lowest in cost of all the processes.

The products of these three processes have many characteristics in common and are classed as regenerated cellulose.

The cellulose-acetate process uses either cotton linters, wood pulp, or the manufacturing waste of its own plants.

Cotton linters are used mostly, and the chemicals are relatively expensive; but there is no waste in the manufacturing process, as the chemicals all go into the product and the broken and tangled filaments are put back and dissolved in the spinning solution. A British company is the sponsor of cellulose acetate. That firm developed celanese, a recent and very popular fabric. The American firm manufacturing this product is an outgrowth of the British company. A number of other manufacturers, both in this country and abroad, are now producing rayon by the cellulose-acetate process. Acele, saraceta, and chacelon are the trade names that some of these firms use for their products.

Manufacturing steps that are common to all kinds of rayon. As has been shown, the main steps in the manufacture of all kinds of rayon are the same. Cellulose, the basis of all synthetic fibers, is extracted from cotton linters or wood pulp. Spruce wood seems best for this purpose, but pine, poplar, and hemlock are also used. Attempts have been made to extract cellulose from other vegetable growths; even the use of cornstalks was for a short time the basis of a hope of relief for the farmers in the corn-growing states. As yet, however, none of these other vegetable products has proved practical. The cellulose is treated with chemicals to produce a gelatinous mass which is forced through tiny holes into filaments. These filaments are hardened either by contact with the air or by being plunged into a chemically treated bath. The filaments are then grouped into the size of yarn required, a twist is put in, and the yarn is wound on bobbins or into skeins ready for use.

This sounds like a simple and easy process, but years of research and experimentation by chemists and inventors of nearly every country have been required to overcome chemical and mechanical difficulties and bring the industry to its present state of success. And their efforts have not ceased.

New chemical treatments and new mechanical devices are constantly improving this new synthetic fiber, and no one can prophesy to what heights of development it may attain in the next few years.

The naming of this new product. All through the first years of its existence this new textile product was called, in general, artificial silk. The name *artificial silk* was, in reality, a misnomer, as rayon differs basically from silk. Silk is an animal fiber, and rayon is a vegetable product. Chardonnet said of his discovery that it was "an artificial textile material *resembling* silk," and that description is accurate. Rayon resembles silk and can be used in many ways as a substitute for silk. But it is not silk. It has not the strength and endurance of silk, and it reacts differently from silk to both physical and chemical tests.

As time went on other names were given to this man-made textile material, until we had a confusion of names such as *wood silk*, *fiber silk*, *vegetable silk*, *manufactured silk*, *glos*, etc. In 1924, however, at a meeting of American manufacturers, the name *rayon* was adopted as the general name of their product. In 1925 the name was officially recognized by the Federal Trade Commission, and has since been used as the generic name for all synthetic fibers made from solutions of modified cellulose, regardless of the process.

The name *rayon* was a happy choice. It was immediately accepted by the buying public, who had been groping helplessly around in the confusion of the many names hitherto used. *Rayon* is a French word having several meanings, one of which is "ray of light," a very appropriate name for this new product. With no knowledge of its derivation, however, rayon is an attractive word, easy to use and suggestive of brightness and sunshine. Some authorities claim that the adoption of this name gave a great impetus to the use of rayon materials.

Increase in use coincident with improvement in quality of rayon. The increased use of rayon since the close of the World War is nothing short of phenomenal. New methods of manufacture have been introduced to increase production and cut down manufacturing costs. New chemical and mechanical treatments have been employed to render the material more beautiful, more enduring, and more suitable for varied purposes. The glassy luster of the early days of rayon has been subdued by improved methods of spinning, twisting, and finishing, and now we have delustered materials with a soft, silky texture. It is the claim of some manufacturers that they can control luster to any desired extent. The stiffness and harshness of feel of the first materials have been entirely overcome, and now we have fabrics with the soft, caressing feel of silk. Its tensile strength, when either wet or dry, has been much increased, and its endurance in handling and wearing greatly improved. The coarse, heavy filaments of the first rayon yarns have been replaced by filaments as fine as if spun by the silkworm. Rayon materials now command respect and are used by all classes of people.

System of numbering rayon yarns. The French system of numbering yarns is used for rayon as for silk, the size being indicated by deniers. A denier is a unit of weight corresponding to 5 centigrams. The fineness of a rayon filament is determined by the weight in deniers of a 450-meter length. It is possible now to spin a filament as fine as 1 denier, which means that 450 meters of this tiny fiber weigh only 1 denier, or 5 centigrams. This is finer than a natural-silk filament. The size of the average rayon filament is from 5 to 10 deniers. As yarn is a group of filaments twisted together to form a thread, the size of a yarn is obtained by finding the weight in deniers of a hank 450 meters long. The average size of rayon yarns is from 150 to 200 deniers, but their present range in size is from 15 to 1200 deniers.

Rayon yarns were formerly graded commercially as A, B, and C. Now they are quoted on the market as first and second grade.

Development of a hollow filament. There has recently been developed in Switzerland a hollow filament which is formed by the mechanical control of air bubbles in the spinning solution. These filaments are lighter in weight and more supple than the solid filaments, and for that reason more can be grouped in a denier of yarn. It is claimed that yarn made from hollow filaments has a lower luster, a greater softness, and a warmer, silkier feel than that made of solid filaments, while at the same time it has almost equal strength. The name of this new hollow-filament yarn is *celta*. It is especially suitable for women's underwear and hosiery.

Dyeing of rayon. As rayon is made from cellulose, which is a vegetable product, it should respond to cotton dyes, and does so in the main. Because of the different chemicals used in the various processes by which rayon is made, however, the dyeing of rayon is not so simple as would at first appear. In the viscose, nitrocellulose, and cuprammonium rayons the fiber is practically regenerated cellulose, and these rayons respond to cotton dyes, having an even greater affinity for dyestuffs than cotton. Celanese and all acetate rayons, however, are made from a chemical compound which is very different in its chemical reactions from regenerated cellulose, of which the other rayons are made. At first it was almost impossible to dye acetate rayon at all, for it has little or no affinity with the dyes usually employed for cotton, silk, or wool. By means of a great amount of study and experimentation, however, chemists have solved the difficulties of dyeing and printing acetate rayon to such an extent that we now have celanese fabrics with a wide range of beautiful colors that are guaranteed strictly fast to sunlight and washing. The peculiar nature of acetate rayon forbids home dyeing,

however, and enterprising housewives, not knowing this fact, have met with disappointment when attempting to dye materials made from this kind of rayon.

Because of the idiosyncrasy of acetate cellulose in connection with dyestuffs, it is possible to produce a multitude of color combinations in cross dyeing when acetate-rayon yarns are combined with other kinds of rayon or with any other textile yarns. Manufacturers have taken advantage of this characteristic and do a good deal of cross-dyeing. Mixtures of viscose and acetate rayons, which have distinctly different affinities with dyestuffs, are now very popular for lining fabrics. With the combinations that can be made of the different textile fibers and the employment of the Jacquard system of weaving, a countless variety of cross-dyed effects can be obtained. Look at the array of exquisitely colored rayon fabrics in our stores today, and see how well the chemists have solved the problem of dyeing and printing rayons.

Care and treatment of rayon. Like all delicate materials, rayon fabrics should be handled gently in the laundry. Most manufacturers of rayon garments give laundering and cleaning directions for the particular kind of rayon used. They usually tell you to wash the article as you would silk, in warm water, with any good soap, and press when damp with a warm (not hot) iron. They advise against hard rubbing, or wringing the garment. One company, however, claims that its products can be washed with hot water, wrung, boiled if necessary, and pressed with a *hot* iron.

With the exception of acetate-rayon materials, the ordinary cleaning solutions commonly found in the average household can be used for removing spots from rayon garments. With celanese, which is an acetate rayon, however, gasoline, benzine, or carbona may be used, but no chloroform, ether, acetone, or glacial acetic acid.

The National Association of Dyers and Cleaners sends out instructions to its members for the identification and cleaning of celanese. The tests are as follows:

1. Moisten the finger with acetone and rub some unexposed portion of the fabric. If the threads feel soaplike and become hard after the acetone has evaporated, this signifies that the cloth is celanese.

2. Celanese cloth or threads melt when tested with a burning match, leaving a hard, black ash.

3. A celanese thread or sample, when dropped into a clean white porcelain, china, or glass saucer containing acetone, dissolves at once.

In regard to the cleaning of celanese, the association warns against the use of chemicals that will wholly or partially dissolve it. More than twenty-five of these chemicals are listed, among which are the following, which are more or less familiar to nearly everyone: acetone, acids (formic, glacial acetic, sulphuric), alcohol and ether, benzol and alcohol, chloroform, fusel oil, grain alcohol, wood alcohol, carbolic acid. Among the cleaning substances that will not dissolve celanese are weak alkalies (ammonia, soap, washing soda, Javelle water), benzol, gasoline, glycerin, naphtha, and turpentine.

Growth in the use of rayon. The birth and spectacular growth of this new fiber, rayon, has almost revolutionized the cloth world. It has produced fabrics with undreamed-of beauty. Not only has it invaded every realm of clothing and house-furnishing materials, but it is found in combination with every other textile fiber. By the aggressiveness of its youth and beauty, it has rejuvenated the staid fabrics that have been with us and done faithful service for so many generations. Consequently we have wool materials enlivened by rayon stripes, checks, and figures. We have materials

with rayon warp and wool filling, and vice versa. We have all varieties of silk-and-rayon mixtures, sometimes produced for beauty but more often to reduce the price of the material. The field of cotton fabrics has been practically reorganized by the mixtures and combinations of rayon and cotton, and the natural beauty of linen napery has been augmented by the lasting colors of rayon introductions.

It is almost impossible to enumerate the many kinds of fabrics that are now being made from rayon. In the field of knitted goods rayon is a very strong competitor of silk in the manufacture of underwear and stockings for women and children. There can now be found rayon underwear, lusterless and run-resisting, and hosiery that only an expert can tell from real silk. Among the pile fabrics rayon has won an enviable place. The combination of rayon with silk in the beautiful transparent velvet is one of its highest achievements. From the broad looms are now being delivered an endless number of materials with familiar names but made wholly or in part from this somewhat unfamiliar new synthetic fiber. Consequently there are rayon voiles, georgettes, chiffons, organdies, and laces; rayon dimities, satins, foulards, and taffetas; crêpes, twills, brocades, and damasks; plushes and velvets, moirés and embossed fabrics. In fact, there seem to be no materials that are made of either cotton or silk that cannot be duplicated in rayon.

Growth in the production of rayon. France was the birthplace of the rayon industry, and it still occupies a high place among the world's producers. One of the largest rayon-manufacturing companies in the United States today is an offshoot of a French company of the same name. Until 1913 Great Britain led the world in the manufacture of rayon. Great Britain is the mother of another one of the large companies in the United States, and now ranks third in the

world's production of rayon. Italy stands second among the rayon-producing countries of the world. A large rayon corporation in the United States is the result of a merger of an Italian company with an American. Germany's industry was greatly disrupted by the war, but that country has so far regained its footing as to rank fourth among the rayon-producing countries. Another large American corporation is a branch of a German concern.

At present the United States is the largest producer, consumer, and importer of rayon in the world. The first rayon-manufacturing plant in America was built at Marcus Hook, Pennsylvania, in 1910. In 1930 this same company had five plants producing rayon, representing an investment of \$90,000,000 and producing over 66,000,000 pounds of rayon annually. In that same year, 1930, there were more than twenty large companies with rayon-producing plants in the United States.

A chart from *Rayon and Other Synthetic Fibers*, 1930 Year Book, published by *Textile World*, New York, shows a growth in production from 38,250,000 pounds in 1924 to 97,701,250 pounds in 1928, and an estimated production of 173,650,000 pounds for 1930.

Only four large companies were producing in 1924, but the growth of those four since that time has been tremendous. In 1928 the United States imported 12,753,989 pounds of rayon. This amount, added to our production of 97,701,250 pounds for that year, makes a total of 110,455,239 pounds of rayon to be used in the United States in one year. Could there be better proof of the popularity of this new fiber?

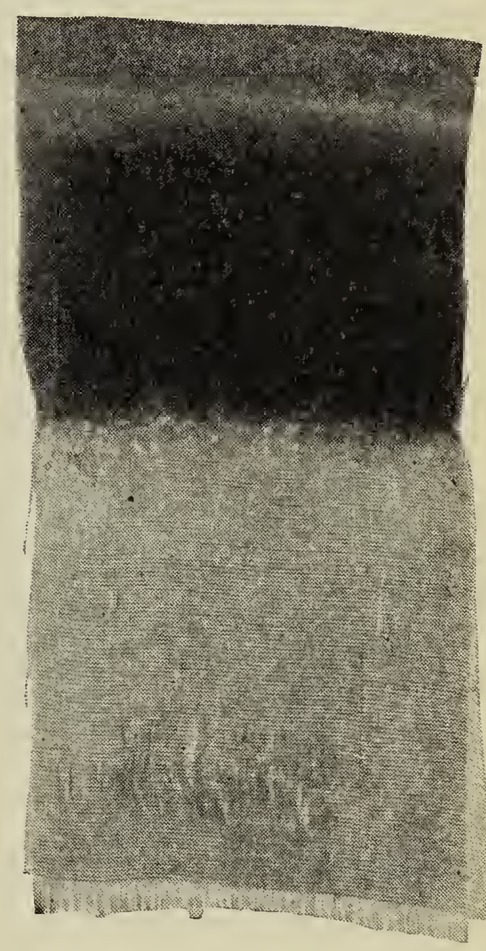
The estimated world production of rayon by countries in 1929 is shown by the following table (taken from the above-named Year Book):

United States	131,325,000 pounds
Italy	50,000,000 pounds
Great Britain	48,500,000 pounds
Germany	44,000,000 pounds
France	38,000,000 pounds
Holland	20,000,000 pounds
Belgium	16,000,000 pounds
Japan	14,000,000 pounds
Switzerland	12,000,000 pounds
Poland	5,500,000 pounds
Australia	4,000,000 pounds
Austria	4,000,000 pounds
Czechoslovakia	4,000,000 pounds
Canada	3,750,000 pounds
Spain	3,000,000 pounds
Brazil	1,000,000 pounds
Hungary	700,000 pounds
Sweden	350,000 pounds
All others	1,000,000 pounds
Total	401,125,000 pounds

The future of rayon. What the future of rayon will be, no one dares to predict. That it is a fiber which has come to stay, there can be no argument. Its coming has been an addition to the textile supply of all classes of people, but to those of small means it has been a great boon. Because of its attractiveness, abundance, and low price it has brought into humble homes fabrics of such rare beauty as could never have been possessed had this fiber remained unknown. Rayon will not take the place of other fibers. It has not the warmth of wool, the endurance of cotton or linen, nor the strength and elasticity of silk. As someone has said, it will not supplant but supplement the other fibers. At present rayon has some serious faults which the scientists are striving to overcome. It is nonelastic, it has less tensile strength when either wet or dry than the other fibers, and there has not yet been found any successful way of waterproofing rayon. But fabrics made from rayon are beauti-

ful and comparatively inexpensive. They never mildew, and neither age nor washing will turn white fabrics yellow. When both the tenacity and elasticity of the fiber are improved, there would seem to be no limit to the use of rayon.

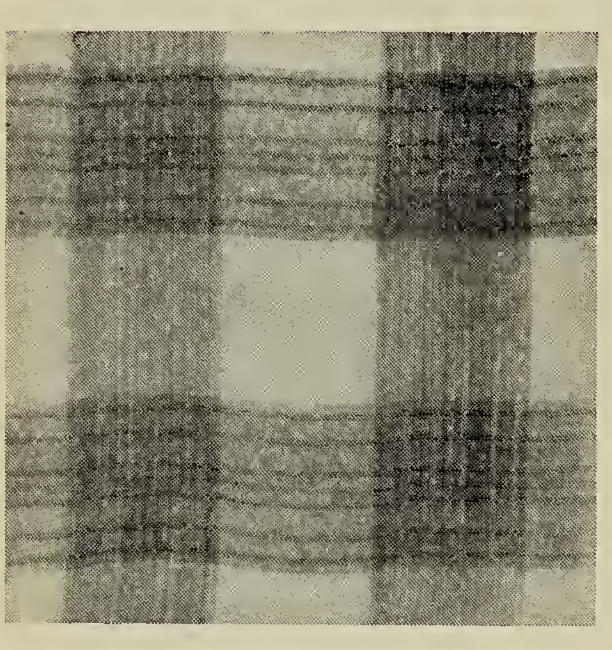
Tests. 1. *To distinguish rayon from silk.* Since the appearance of cellulose-acetate rayon and the great improvement in the quality of all rayon yarns it has become almost impossible to give simple directions for distinguishing between silk and rayon. The coarse, stiff rayon yarns of a few years ago that were so easy to distinguish from silk are not found at all today. The microscope can no longer render an infallible decision between these two fibers. The structure of high-grade rayon yarns is so similar to that of silk that the microscope finds difficulty in revealing the identity of the specimen. The familiar burning test that is used so commonly to distinguish between silk and cotton is still useful with viscose, nitrocellulose, and cuprammonium rayons. But acetate rayon burns much like silk and leaves a similar residue.



TRANSPARENT VELVET WITH ACETATE-RAYON PILE REMOVED BY MEANS OF THE FLATIRON TEST

The flatiron test, which removes vegetable fibers from a wool-and-cotton or a silk-and-cotton mixture, will likewise destroy all rayon present. With a glass rod spread a drop of 2 per cent sulphuric acid on the sample and place between layers of papers. Put a hot iron on top of the papers and leave

it there until the sample is dry. When rubbed between the fingers, the carbonized rayon will fall out of the sample. (If a sample is chosen which has rayon yarns in one direction and silk or wool in the other, the result is striking. Startling effects are also obtained by treating a piece of transparent velvet in this way. The rayon pile will disappear, leaving intact the silk background.



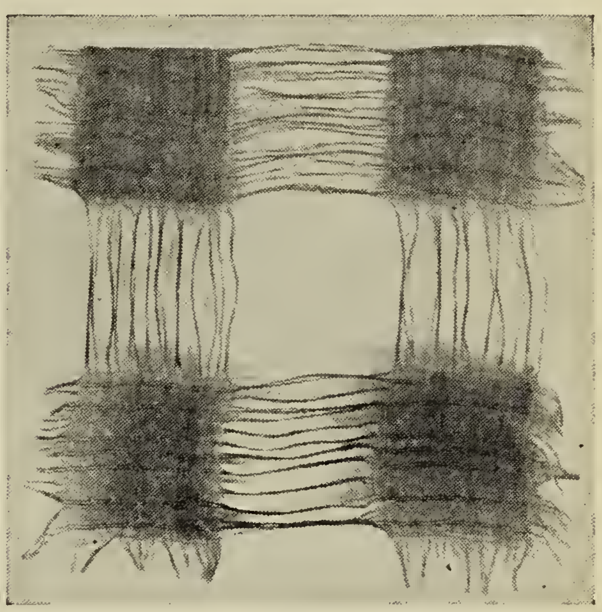
SAMPLE OF A RAYON MIXTURE

2. *To distinguish acetate rayons from other rayons.* Viscose, nitrocellulose, and cuprammonium rayons burn with a flash, leaving a white ash. Acetate rayons (celanese, etc.) seem to melt and sputter, leaving a black cinder similar to that left by silk.

A simple chemical test is as follows: Place a sample of rayon in a small porcelain or glass dish and pour over it glacial acetic acid or acetone. Cellulose-acetate-rayon yarns will immediately dissolve, and the others will remain unchanged.

By-products and other products of rayon. 1. *Waste.* As in the manufacture of any other kind of textile yarn, there is a certain amount of waste in the manufacture of rayon. Unless the plant consumes this waste by dissolving it in the spinning solution, as is done in the case of acetate rayon, this waste is of no use to the rayon manufacturer. It is therefore sold to be mixed with cotton or wool and spun into yarns that are to be used for blankets, sweaters, coatings, and other inexpensive heavy cloths. These short and broken filaments are also carded, combed, and twisted into yarns called spun rayon. Spun rayon is used in mixtures, pile fabrics, etc.

2. *Staple fibers.* Because of the popularity of mixture fabrics made with the introduction of rayon waste, short lengths of rayon are now being produced by several firms to be used in this way. These are called staple fibers and are made by the same processes as other rayon yarns, except that filaments after passing through the neutralizing bath are bunched together and cut into lengths of from four to eight inches. Staple fiber is considered superior to rayon waste for spinning with other textile fibers. It also produces an excellent grade of spun rayon.



SAMPLE SHOWING ACETATE–RAYON YARNS REMOVED BY GLACIAL ACETIC ACID

3. *Sase.* Sase is the name given to a kind of spun-rayon yarn used chiefly for knitted or pile fabrics. The filaments are made in Germany by the viscose process. The fineness is due to stretch spinning. The fibers are cut and spun into a yarn which does not resemble rayon but appears more like spun silk or mercerized cotton. It is most commonly found in infants' shirts.

4. *Artificial wool.* One of the other products that have been evolved through the manufacture of rayon is artificial wool, or *sniafil.* Sniafil was first produced in Italy but is now also being manufactured in France. The fiber resembles wool in appearance but does not have the strength or warmth of wool. It is soft and lustrous, does not cause itching, and is moth-proof. It is made of short ends of fine yarns, carded, combed, and spun into yarns as in the case of natural wool.

Artificial wool combines well with natural wool, and costs less than half as much per pound.

5. *Artificial horsehair.* Artificial horsehair, or monofil, is a rayon product. The advantage of this "synthetic hair" is that *long* hairs can be produced which are convenient for braids, millinery, hair nets, wigs, pile carpets, rugs, etc.

6. *Artificial straw.* Rayon straw, or visca, is also a rayon product and is used for millinery braids.

7. *Films.* The cellulose-acetate process, since its perfection, has replaced the other processes in the making of photographic films, as they are thereby rendered less inflammable.

8. *Cellophane.* Cellophane is a rayon product which is made in transparent sheets resembling isinglass or photo films. It can be dyed, etched, lacquered, embossed, crimped, and plated. It is known as glassolyn, flexaloid, fenester paper, etc. It is used for bottle caps, wrappers for cosmetics, fancy wrappings, etc.

9. *Unshatterable glass.* The comparatively new kind of glass that is becoming so popular for automobiles, because it does not scatter when broken, is made with the use of a nitrocellulose or cellulose-acetate filler. This filler is a sheet which is placed between two sheets of glass, to which the glass adheres so tenaciously that when it is broken the splinters will not scatter.

10. *Other uses of cellulose.* Because of its impenetrability to water, experiments are being carried on with the use of a cellulose solution for surfacing paper, for waterproofings, for sizings, for mixing with paints to give a harder, glossier surface, for mixing with rubber, etc. Attempts are being made to use a form of this product for sausage casings and for other food wrappings and containers.

There seems, in fact, such a wide variety of uses to which this new substance can be adapted that one can scarcely keep up with the different forms in which it is appearing. Cellu-

lose, which is the basis of all plant structure, has become a great friend to man. With the large number of chemists, both in this country and abroad, who are devoting their time to the study of this substance, it is probable that the cellulose products of the future will furnish many new and perhaps startling benefits to mankind.

QUESTIONS AND ASSIGNMENTS

1. What is the basic difference between rayon and all the other textile fibers?

2. Mount and describe ten samples of rayon materials and five samples of rayon mixtures.

3. Why is rayon particularly good for linings?

4. When and where was established the first rayon factory in the world? in the United States?

5. How many processes are used at the present time in making rayon? Which one has the greatest production?

6. What proof have we of the popularity of rayon in the United States?

7. Give five ways in which rayon differs from silk; from cotton.

8. Why is rayon not used for umbrellas? for sewing thread?

9. Give two trade names of acetate rayons. How do acetate rayons differ from the other kinds of rayon?

10. In what way would a white sports suit of rayon be more satisfactory than one of silk?

11. In as many ways as possible, compare with a similar article in silk of about the same quality the following:

a piece of rayon moiré
a rayon undergarment
a piece of rayon lace

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See page 369.

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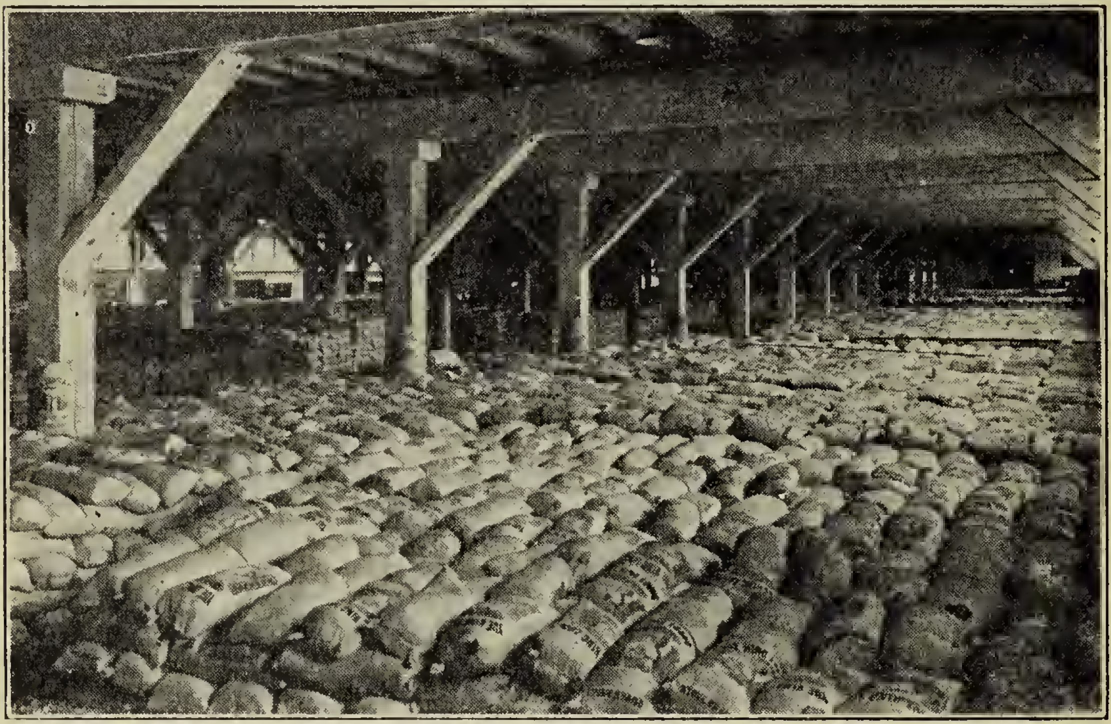
CHAPTER XVIII

CLOTH A PRIME FACTOR IN MAN'S DEVELOPMENT

Living conditions in prehistoric times. That the general use of textile materials is of comparatively recent date is now evident. We have no means of determining for how long a period of time our prehistoric ancestors were obliged to use only raw materials where we now depend upon manufactured products. The relics of those early days which have been unearthed and interpreted by scientists and historians show that for his clothing primitive man threw the skin of a wild beast over his naked body; for his home he crawled into a cave in the rocks or climbed to a safe place among the branches of a tree; for receptacles in which to carry his food of nuts and berries he increased the capacity of his hands by using the large, coarse leaves that grew about him; his weapons were at first his strong arms and hands, which he afterwards extended by a grasped branch or a thrown rock; his tools he selected from among the shells and stones; and for his means of transportation his own vigorous body was his only vehicle. The contrast between these crude conditions and our own comfortable manner of living strikingly reveals the evolution of the simple human creature of that shadowy, far-away time to the highly accomplished being of the present day.

Living conditions today. To what extent the discovery and use of cloth have contributed to the growth of man's intelligence we shall never know, but as we enumerate some of our present uses of textile materials we begin to appreciate their importance in civilized life. Instead of wearing the

skins of animals for clothing, more than 500,000,000 people are now dressed in textile fabrics. In place of trees and barren caves as abodes, millions of homes are made comfortable and attractive by the use of textile furnishings. In contrast with the natural food containers of our prehistoric



SACKS OF FLOUR IN WAREHOUSE

A use of cloth not often thought of. (Courtesy of Port of Seattle)

ancestors, today millions of yards of cloth are made up annually into sacks and bags[1] to be used by the cotton planters for baling their bulky crop and by the sheep growers for their fleeces, by the farmers for holding their grain and vegetables and by the millers and manufacturers for these same products in other forms. By every civilized nation the simple weapons of primitive man have been replaced by highly organized army and navy departments in which cloth is indispensable. During the late war textile materials for

[1] One large concern pays out $1,000,000 a year for the thread used in sewing the bags it manufactures.

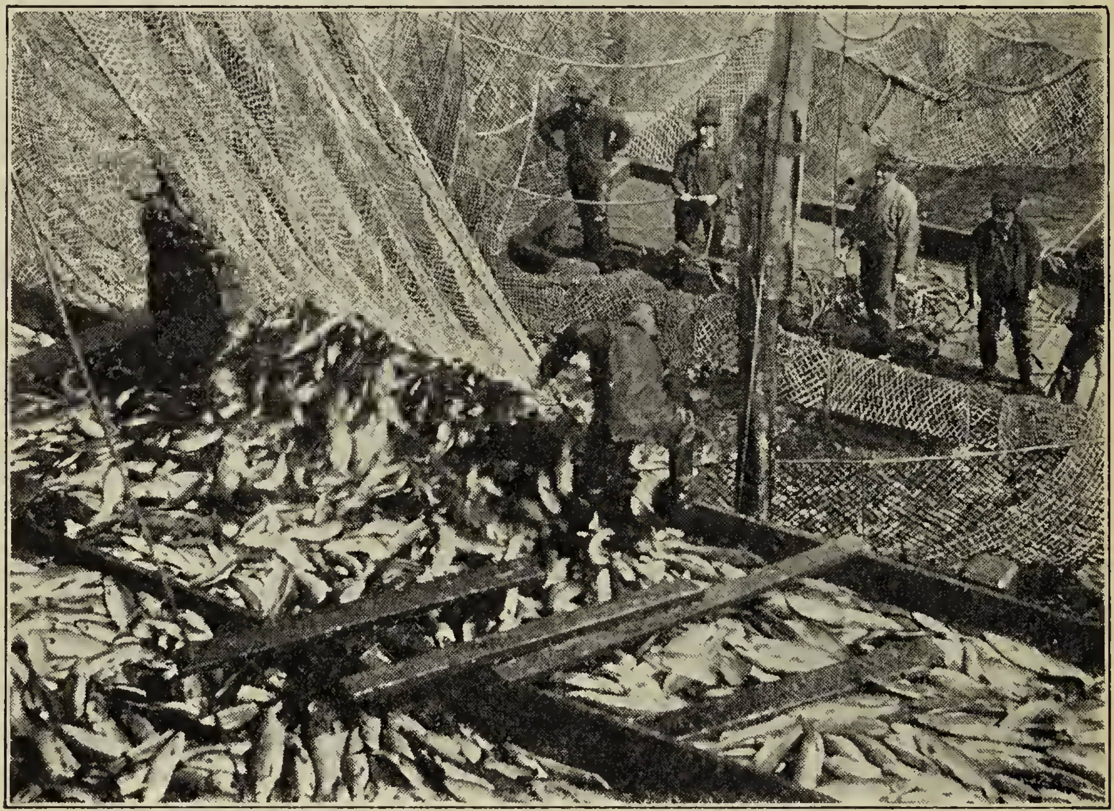
our army and navy were contracted for in huge quantities. The report of the Quartermaster General of the United States army shows such items as 25,000,000 towels, 22,000,000 blankets, 300,000,000 yards of various kinds of duck, among the purchases of war supplies. At one time airplane cotton was being produced at the rate of 1,200,000 yards per month.

Primitive man had no trades, and his occupation consisted chiefly in securing his food and eluding or overcoming his enemies. The range of civilized man's productive activities extends from the simplest unskilled labor to the most intricate scientific endeavors, and throughout the entire list of professions, businesses, and industries, cloth, to a greater or less extent, is an essential adjunct. Some of the uses of cotton for surgery and hospital purposes are enumerated in Chapter XII. In religious life costly and beautiful forms of textile materials have always been employed. ("One of the cloth" is frequently used to designate a member of the clergy.) Certain great occupations, like the vast fishing industries of our Eastern and Western coasts, are practically dependent upon the strong cord which is made into all kinds of nets, seines, cordage, and fishing tackle; while for mechanical purposes a prominent mechanical engineer[1] makes the statement, "Practically no industry exists that does not depend in some degree upon mechanical cloths."

Just a partial list of uses to which cloth is put in the field of mechanical industries may surprise us with the necessity of textile materials here. Cloth is used for absorption, aprons, backings, belts, binders, buffers, bumpers, carriers, cleaners, containers, conveyors, covers, distributors, fabric bases, facings, filters, flame protectors, gaskets, grips, hose, insulating, jacketing, laminated materials, linings, packings, paddings, polishing, pressing, screens, sieves, slings, straps, tracing, tubing, washers, webbing, wicks, and windings.

[1] James W. Cox, Jr.

Contrasted with primitive man's slow and laborious means of transportation, civilized man is carried over land and water and through the air at a high rate of speed and with little effort. Consider for a moment the dependence of our present-day vehicles upon textile materials. For the tires, cushions, and coverings of the increasing millions of



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SALMON FISHING ON THE PACIFIC COAST

Note the nets used

automobiles textile fabrics and cords are indispensable. Although canvas sails[1] are fast disappearing from our shipping circles, all water craft require ropes, cords, hose, tubes, etc. in their equipment, while the amount of cloth used for utility and decorative purposes in our modern passenger steamships is almost beyond belief. Our latest means of travel and trans-

[1] The making of sailcloth was one of the first textile industries in the United States, a factory for this purpose having been established at Boston in 1788.

portation, that through the air, is practically dependent upon the textile world, as in the construction of heavier-than-air craft certain kinds of cloth are absolutely essential. For some flying machines nearly 800 square yards of fabric are used for the wings, and a giant dirigible requires approximately 150,000 yards to cover the frame.

We hear nothing of the games and sports of prehistoric man, but today our national life contains a highly organized

A DIRIGIBLE,—ONE TYPE OF MODERN AIRCRAFT

Courtesy of the Naval Aircraft Factory, Philadelphia, Pennsylvania

world of sports which could not exist without textile materials. Besides the variety of fabrics required for the athletic suits of the participants, textile materials are frequently needed for the game itself. In our ball games the tennis ball, baseball, handball, football, and basketball require cord or cloth in their construction. Nowadays, wherever the climate will permit, people try to escape for a time from the conventional routine of living and get "back to nature." In camping we return to some of the conditions of our prehistoric ancestors, but what differences have been brought about by the use of cloth! Civilized man has a tent to live in, a cot to sleep on, blankets to keep him warm, and gauze or netting to protect him from troublesome insects. These

are comforts that could not be imagined by primitive man and could not now exist but for the use of cloth.

Use of cloth parallel to stage of civilization. This brief contrast between the barren existence of early man and the comfortable, diversified life of his present-day descendant shows that the knowledge and use of cloth have been

COVERING A GIANT DIRIGIBLE

Courtesy of the Naval Aircraft Factory, Philadelphia, Pennsylvania

important factors in man's development. If we could analyze all the innumerable phases of modern life, we should be increasingly amazed at its dependence upon the fabric world. One of Carlyle's writings[1] has for its doctrine "Society is founded upon cloth." As we study the history of textiles we see that the increase in the kinds and uses of cloth has kept pace with the growth of civilization throughout the ages.

[1] Sartor Resartus.

QUESTIONS AND ASSIGNMENTS

1. Give the names of all the textile materials in any one room in your home and describe their uses.

2. What textile materials are necessary in your father's business? in your own games and sports?

3. How does cloth assist in developing patriotism?

4. Give ten uses, other than for clothing and house furnishings, for plain white cotton cloth.

5. Visit your local dry-goods or department store. Is there any department in which no textile materials can be found?

6. How do the railroads use textile materials?

7. Where is your nearest textile mill? What does it manufacture? How many people does it employ? Where does it sell its products?

8. Schools and libraries contain much of a certain kind of cloth. How is it used?

9. Write a review of one of the references given.

10. Of what importance is the textile industry to our country? Quote from recent government statistics.

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See page 369.

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GLOSSARY OF MATERIALS

This Glossary is in no way intended for a complete cloth dictionary. It is simply to assist in the quick identification of materials named in the text.

A B C silk. A light-weight lining material with cotton warp and spun-silk filling. Plain weave, white or plain colors, and only one grade. Used for linings and underwear.

Acele. The trade name of a certain manufacturer for his cellulose-acetate-rayon materials.

Airplane cotton and linen. Strong linen or mercerized cotton material with plain weave, made to exact specifications for the wings of airplanes. After the World War the surplus was sold in retail stores for civilian purposes. Used for shirts, house dresses, children's garments, etc.

Alpaca. A smooth, lustrous, wiry fabric. Originally made with cotton warp and filling of pure alpaca. Now made with cotton warp and filling of mohair or any lustrous wool. Used for linings, dresses, and men's summer coats and suits. Different grades and weights called Angora, brilliantine, sicilian, mohair, Palm Beach cloth, etc.

Angora or *mohair.* Angora or mohair fiber used particularly in braids, automobile tops, and pile fabrics for blankets, upholstery, artificial furs, etc. *See* Alpaca.

Artificial silk or *rayon.* A manufactured fiber made in imitation of natural, or worm, silk. Artificial-silk materials closely resemble those of silk and are used for the same purposes. Artificial silk is often combined with other fibers for all kinds of woven and knitted fabrics. Called at first fiber silk, vegetable silk, wood silk, glos, etc.

Asbestos. A fireproof, undyed material woven or pressed from asbestos, a mineral fiber. Used for acid filters, fireproof stage curtains, gloves, and other garments or articles to be used around fire or great heat.

Astrakhan. A pile fabric made in imitation of the real Astrakhan fur and used for the same purpose. The curly, lustrous pile is usually of mohair.

Awning cloth. A heavy canvas or duck, usually with wide, bright stripes. Used for awnings, hammocks, etc. *See* Canvas *and* Duck.

Axminster rugs and carpets. Carpeting with long, soft pile (on one side), originally hand tufted. First made in Axminster, England, on hand looms. Now machine woven. *Compare with* Wilton.

Balbriggan. The name formerly stood for fine, strong knitted undergarments made of Egyptian cotton. Now applied to certain kinds of unbleached knitted underwear.

Baronette satin. A novelty satin with warp of artificial silk and filling of cotton. Has brilliant luster but is stiff and rather coarse. Used for sports wear, trimmings, and decorative fabrics.

Bathrobe material. A thick, soft, light-weight cotton fabric, heavily napped on both sides. Colored figures and background usually reversible on face and back of cloth. Used for bathrobes, infants' blankets, etc.

Batiks (bä'tēks). Fabrics, either silk or cotton, that have been colored by the batik process of printing, originated by the Javanese.

Batiste (ba tēst'), from *Jean Baptiste.* A soft, fine cotton fabric, either white or in delicate tints. Better grades highly mercerized. Used for baby clothes and fine lingerie.

Beach cloth. A rather coarse cotton material in white or plain colors, somewhat resembling linen crash. Used for dresses and children's suits.

Bed ticking. A strong, closely woven, twilled cotton material usually found in blue and white or brown and white stripes. Yarn dyed. Used for feather beds, mattresses, pillows, etc.

Bengaline (from *Bengal*). A heavily corded silk material in white or plain colors. Used for dresses, coats, suits, etc. Not always in style.

Birdseye. A white linen or cotton material, the design of which is a small diamond figure with dot in center resembling a bird's eye. Used for towels, and for diapers and sanitary napkins. Also called diaper cloth.

Bobbinet. A plain lace material of hexagonal mesh. Coarser and heavier weights used for curtains; finer and lighter weights for linings and trimmings.

Bolivia. A soft, warm, light-weight pile fabric used for women's and children's coats. When it is in vogue there are many similar fabrics bearing different names.

Brilliantine. See Alpaca.

Broadcloth. A fine, soft, double-width wool material with a smooth nap on the face. Better grades very lustrous. Used for dresses, suits, and coats. Cotton broadcloth used for shirts, dresses, pajamas, etc.

Brocade silks. Silks with a conspicuous woven figure made by the Jacquard loom.

Brussels carpets and rugs. Carpeting with a plain back and looped pile on the face.

Buckram. A coarse, heavy, and very stiff cotton or linen material. Sometimes made of two fabrics glued together. Used for the stiffening in women's hats, men's coats, etc.

Burlap. A coarse, rough material made of jute. Cheaper grades used for gunny sacks. Better grades dyed or printed and used for draperies.

Butcher's linen. A firm, bleached linen material made with rather coarse yarns. Originally used for coats and aprons of men in meat shops. Replaced now by cotton for utilitarian purposes. Used for table linens, doilies, runners, etc.

Calico (from *Calicut*, name of a city in India). A low-grade, printed cotton material, sometimes called print. Used for inexpensive dresses, aprons, shirts, etc. Now largely replaced by percale.

Cambric (from *Cambrai*, name of a city in France). A fine, thin, polished cotton material found in various weights, qualities, and finishes. Used for baby clothes, lingerie, and linings.

Camel's hair. A soft, napped coat material, usually tan-colored. Originally made of natural-colored camel's hair. Now often made of a good quality of wool and dyed to color. Used for coats, capes, wraps, etc.

Camel's hair. A soft, warm wool material with loose, glossy fibers on the face. Used for dresses.

Canton crêpe (from *Canton*, name of a city in China). Heavier than crêpe de chine but similar in appearance. *See* Crêpe de chine.

Canton flannel. A firm and rather heavy cotton material made of soft yarns in the serge weave with a long, heavy nap on the face. Used for silence cloths, men's work gloves, warm underwear, etc.

Canton linen. A smooth, rather stiff fabric made of ramie fiber and having a glassy luster. Made in the Orient. Also called grass cloth, grass linen, Chinese linen, China grass cloth, and ramie. Used for lunch cloths and doilies, and for decorative household purposes.

Canvas. A general name for a class of heavy, plain-woven material made of either cotton or linen. Used for tents, sails, awnings, interlinings, tarpaulins, etc. Some kinds of canvas are used for art purposes.

Cartridge silk. Silk material made for holding the charges for big guns. After the World War much cartridge silk was released and used for civilian purposes.

Cashmere. A fine, soft, twilled wool material almost never found now. Originally made of fiber from the Cashmere goat. The name *Cashmere* is now applied to soft wool hosiery containing some cotton.

Celanese. The trade name of a certain firm for its rayon products. Celanese was the first fabric produced by the cellulose-acetate process.

Celta. A hollow rayon filament. Used for knitted goods and hosiery.

Chacelon. The trade name of a certain firm for its rayon products made by the cellulose-acetate process.

Challie or *challis* (shăl'ĭ). A fine, soft, plain-woven wool material, usually printed. Not always in vogue. Used for blouses and women's and children's dresses.

Chambray (shăm'brā). A fine cotton material, usually made with a colored warp and white filling. Resembles gingham in weight, structure, and finish. Used for men's shirts, women's dresses and aprons, and children's clothes.

Chamoisette (shăm wa̭ sĕt'). A fine, firmly knitted cotton material with a nap so short and soft as closely to imitate chamois skin. Used for fabric gloves.

Changeable silk. See Shot silk.

Charmeuse (shär'mûz'), "a charmer." A soft, beautiful satin material. Comes in different grades, sometimes with wool back. Used for gowns. Cotton charmeuse is made in imitation of the silk.

Cheesecloth. A cheap, loosely woven cotton material formerly used for holding cheeses in the process of making. Different qualities of cheesecloth from which the natural wax of the cotton fiber has been removed are used for absorbent purposes in surgery. Called hospital gauze, surgeon's gauze, etc.

Chenille (shē nēl'), "a caterpillar." A thick, fluffy, light-weight pile material, alike on face and back. Usually of wool but may be of silk or cotton. Loosely woven of a yarn made especially for the purpose. Found in plain colors or elaborate woven designs. Used for draperies and hangings. Not always in vogue.

Cheviot. A somewhat harsh and hairy material originally hand woven from the strong, coarse wool of the Cheviot sheep. Now made commercially of any coarse wool. Also found in cotton and cotton mixtures. Different weights used for dresses, suits, coats, etc.

Chiffon (chĭf′ŏn; French, shē fôn), "a rag." A thin, sheer, almost transparent silk material formerly used for veilings, trimmings, and millinery purposes. Used for dresses and dainty underwear. Not always in vogue.

China grass cloth. See Canton linen.

Chinchilla. A heavy wool double cloth with a curly pile on the face. Named from Chinchilla fur, which it originally resembled. Used for coatings.

Chinese linen. See Canton linen.

Chintz. A firmly woven, smooth, printed cotton material. Design usually made of small, closely distributed floral figures. Used for curtains, trimmings for hangings, etc.

Chintz, English. Heavily glazed, printed in large floral designs, and used for bedspreads, dustcovers on furniture, etc.

Corduroy (côr′du̯ roi), from French *corde du roi*, "king's cord." A fabric, usually of cotton, with lengthwise rows, or cords, of pile on the face. Found in white or any plain color. Much used for suits and trousers for men and boys, lounging robes and sports wear for women, coats and wraps for children. Found also in wool. Certain qualities used for hangings and upholstery.

Cotton felt. An undyed cotton material, heavily napped on both sides, used for silence cloths under tablecloths.

Cotton foulard. A cotton imitation of silk foulard. *See* Foulard.

Cotton gabardine. Cotton material of same weave as wool gabardine. Used for dresses, skirts, blouses, etc. *See* Gabardine.

Court plaster. A thin silk or cotton material treated on one side with a medicated glue which will adhere to the skin. Found in white, flesh color, and black. The beauty patches of Colonial times were of black court plaster.

Covert cloth. A smooth, twilled material of wool, cotton, or a mixture, with a fine-specked appearance caused by the twisting together of white and colored singles to make the warp yarns. Used for riding habits, suits, coats, and wraps. Frequently cravenetted or rubberized for rainproof garments.

Crash. A coarse, rough, plain-woven fabric found in cotton, linen, and union materials. May be unbleached, partly bleached, white, or dyed. Found in many widths and qualities. Used for towels, covers, and decorative household articles. At times fashionable for suits and dresses.

Crêpe (krāp), "curled." A general term applied to materials having a pebbly effect produced by twists in the yarns and by varying the tension in weaving. *See* Crêpe de chine, Georgette crêpe, Japanese crêpe, *and* Serpentine crêpe.

Crêpe de chine (krāp d' shēn'), "crêpe of China." A light-weight, closely woven silk material, alike on face and back. In white and plain colors. Many weights and qualities, but almost always satisfactory in wear. Found in cotton, silk, and mixtures. Used for blouses, gowns, trimmings, lingerie.

Cretonne. A medium-weight cotton material usually printed with elaborate floral designs. Found in various qualities, the better ones often warp printed. Used for pillows and draperies and for decorative household articles.

Crossbar dimity. Dimity with a heavy cord at regular intervals in both warp and filling. *See* Dimity.

Damask (from *Damascus*). A smooth material, usually of Jacquard weave, made originally of silk, now made of linen, cotton, or mixtures. Found in many widths and a great variety of designs. Formerly much used for towels. Used for tablecloths and napkins. Pattern cloths and napkins are woven to size with the entire design on each. Damask made of wool or heavy silk is used for draperies and upholstery. *See* Satin damask.

Denim. A firm, strong, twilled cotton material usually found in dark blue or brown. Formerly had specked effect produced by twisting a white ply into the filling yarn. Used for men's overalls and jumpers and for children's rompers and play suits. Certain qualities are used for draperies, couch covers, etc.

Devonshire. A strong, yarn-dyed cotton material much used for house dresses, children's rompers, nurses' uniforms, etc.

Diaper cloth. See Birdseye.

Dimity. A fine, crisp, light-weight cotton material, white or in plain colors. Used for aprons, dresses, and underwear. *See* Striped dimity *and* Crossbar dimity.

Dotted Swiss or *Dotted muslin.* Swiss, or muslin, having a pattern of dots woven in at regular intervals with soft, heavy yarn. Many qualities. Used for aprons, curtains, trimmings on wash dresses, etc. *See* Swiss.

Double cloth or *Double-faced cloth.* Any fabric which is made by the use of more than one warp or filling in its construction, or by the simultaneous weaving and fastening together of two or more cloths. Examples, bathrobe material, Marseilles counterpanes, steamer rugs. Name usually applied to double cloth used for suits and coats.

Drill or *Drilling.* Strong, twilled cotton material. White, unbleached, or colored. Many grades. Used for middy blouses, summer trousers, heavy linings, etc.

Duck. A close, heavy cotton fabric of plain weave. Sometimes two yarns used as one in the warp. White or colored. Many widths and weights. Heavy grades practically water tight and used for tents, awnings, sails, tarpaulins, sea kits, etc. Lighter weights used for clothing. *See* Canvas, Awning cloth, *and* Sailcloth.

Duvetyn (doo-vẽ tēn′), from French *duvet,* "down." A soft, lightweight material of silk, wool, or a mixture, with a downy nap raised by emery rollers. Used for suits, wraps, and millinery. To a considerable extent it replaces velvet.

Eiderdown (from the down of the eider duck). A light-weight knitted material with a thick, fluffy nap of wool on one or both sides. Formerly much used for bathrobes, baby blankets, etc. Now replaced somewhat by bathrobe material.

Farmer's satin. A mercerized cotton lining material of satin weave and high polish. May be plain, colored, or printed. Also called Venetian. Used for linings.

Felt. A wool material with the fibers so matted and pressed together as entirely to obscure the method of construction. High-grade felts are woven; common felts are not woven, but are made by shrinking and matting the fibers together. Many weights and qualities. Used for billiard-table and card-table covers, pads to prevent scratching of furniture, slippers, pennants, rug linings, etc. *See* Cotton felt.

Fiber silk. See Artificial silk.

Flannel. A soft, light-weight wool material slightly napped on both face and back. In white and plain colors. Used for middy

blouses, men's shirts and sports trousers, dresses, underwear, and children's clothes.

Flannelette. A light-weight cotton material napped on the face. May be white, dyed, or printed. Used for kimonos, sleeping garments, dressing sacques, and gowns.

Flaxon. A smooth, crisp, light-weight cotton material resembling dimity. Found plain or with cords. White, tinted, or with printed figures. Used for aprons, lingerie, infants' wear, etc.

Foulard (fōō-lärd′; French, fōō lär′), "silk handkerchief." A soft, firm, light-weight silk material of plain or twill weave, usually printed. Wears well. Used for kimonos, gowns, linings. *See* Cotton foulard *and* Shower-proof foulard.

Gabardine or *Gaberdine.* A firm, smooth, wool dress material woven with a steep twill. Many weights and qualities. Used for suits and gowns. *See* Cotton gabardine.

Gauze (hospital or surgeon's). *See* Cheesecloth.

Georgette crêpe. An almost transparent silk material found in white and plain colors; also printed. Used for blouses, gowns, trimmings, dainty lingerie, etc.

Gingham. A firm, smooth cotton material, usually yarn dyed and woven in checks, plaids, or stripes. Sometimes found in white and plain colors. Many weights and qualities. Used for children's clothes, women's dresses, aprons, nurses' uniforms, etc.

Glacé silk. *See* Shot silk.

Glos. *See* Artificial silk.

Grass cloth. *See* Canton linen.

Grass linen. *See* Canton linen.

Grenadine. A thin silk material made with gauze weave. Much used a few generations ago for women's dresses. Seldom found now.

Gummed tape. A thin, firm cotton material gummed on one side. Used for mending torn music sheets, book leaves, etc.

Haircloth. Material made with cotton or linen warp and horsehair filling. Hair filling thrown to face by satin weave. Formerly used for upholstery. Now used for millinery and stiffening in coats.

Handkerchief linen. A fine, soft linen material used principally for handkerchiefs. Found in white and plain colors. Also used for infants' wear, lingerie, blouses, etc.

Homespun. A coarse, strong wool material made of rough yarns

in mixed colors. Originally hand woven in the homes of Scotch and Irish peasants. Now made commercially. Similar to tweed. Used for overcoats, caps, and sports suits for both men and women.

Hospital gauze. See Cheesecloth.

Huckaback. Commonly called huck. A linen material originally peddled by hucksters in the British Isles. Name now applied to cotton, linen, or union materials woven with the small figured design found in all huckaback. Used for towels.

Ingrain carpeting. A yarn-dyed three-ply carpeting woven on a Jacquard loom with coarse wool. Pattern reversible on face and back.

Japanese crêpe. A rough cotton crêpe, in white and plain colors. Does not require ironing when laundered. Used for children's clothes, women's dresses, aprons, etc.

Jersey. A general name given to plain-knitted material used for garments. May be of cotton, wool, silk, artificial silk, or a mixture of fibers. Great variety of weights, qualities, and colors. Used for knitted underwear, blouses, gowns, suits, coats, etc.

Khaki (kä'kē), from East Indian, "dust-colored." A strong twilled cotton material of dust color used for uniforms of American soldiers. Many weights and qualities. Made for civilian purposes. Used for Boy Scout suits, summer suits for men and women for outdoor work, camping, fishing, tramping, etc.

Kimono silk. A soft, plain-woven, light-weight silk, usually printed in elaborate designs. Used for kimonos, linings, etc.

Lace. Materials of open structure made either by hand or on lace machines. Used for trimmings and decorative articles.

Linene. A cotton material finished to imitate linen. Finish destroyed by laundering.

Linoleum. A floor covering made by using a specially prepared heavy paint on a strong burlap or hemp foundation. Many grades. Highest grade is inlaid. *See* Oilcloth.

Linon. A cotton imitation of handkerchief linen. *See* Linene.

Linsey-woolsey. A material never found now. A durable but unattractive material of wool and flax, hand spun, home dyed, and hand woven by our Colonial ancestors. Used for dresses of the women and children.

Longcloth. A fine, smooth, light-weight, closely woven cotton material with soft finish. Used for infants' clothes and lingerie.

Mackinaw. Heavy wool coating, usually of double cloth, yarn-dyed and woven in plaids. Used for coats for men, women, and children. Worn especially by loggers, trappers, etc.

Madras (from *Madras*, name of a city in India). A firm, smooth, soft-finished cotton material similar to a good quality of gingham. Usually yarn dyed and often contains small Jacquard design. Used for shirts, pajamas, etc.

Madras. A material of gauze weave having a pattern woven in with soft, heavy yarns, the cut ends of which give a shaggy effect to the back of the material. Used for curtains and draperies.

Marquisette. An open silk or cotton material of gauze weave similar to grenadine. May be made of mixed fibers. Many grades. Used for dresses, curtains, etc.

Marseilles (mär sālz′), from *Marseilles*, name of a city in France. A cotton double cloth, often with elaborate floral design, the pattern being made by the releasing and combining of the different ply as the cloth is woven. Used for bedspreads.

Metalcloth. A brilliant, metallic material made with a cotton warp and filling of metal novelty yarns. Used for millinery, trimmings, lamp shades, etc.

Metalline cloth. A material of bright metal colors and brilliant luster. Made with silk or cotton warp and artificial silk filling. An imitation of metal cloth and used for the same purposes.

Milanese (from *Milan*, name of a city in Italy). A silk underwear material knitted on a warp-knitting frame. Does not ravel. Used for underwear, gloves, hosiery, etc.

Mohair. See Angora.

Moiré (mō′rā; French, mwä rā′), "watered" silk. A silk material (usually poplin) with a watered effect on the face. Finish produced by heat, moisture, and etched rollers. Used for millinery, wraps, gowns, trimmings, etc.

Monk's cloth. A coarse, rough cotton material with conspicuous basket weave. Usually dust-colored but may be dyed. Used for draperies, couch covers, etc.

Monofil. An artificial (rayon) horsehair. Used in millinery, braids, etc.

Mummy cloth. A cotton or linen toweling of irregular weave giving a pebbly effect. Used for towels, runners, etc.

Muslin. A general term for plain white or unbleached cotton materials used for underwear and household purposes.

Nainsook. A fine, smooth, soft cotton material, usually white but may be tinted. Many grades. Used for infants' wear and lingerie.

Near-silk. A mercerized cotton lining material.

Net or *netting.* An openwork material usually made on the lace machine. Forms the foundation for a great variety of laces. Used for curtains, millinery, etc.

O. D. flannel. An olive drab flannel made to exact specifications by the United States government for the uniforms of our soldiers.

Oilcloth. A material painted on one side with a specially prepared paint. Lighter weights used for kitchen aprons, table and shelf coverings, etc. Coarser and heavier grades used for floor coverings. *See* Linoleum.

Oiled silk. A light-weight silk material treated with a special preparation to make it waterproof. Used for waterproof garments and toilet purposes.

Organdie or *organdy.* A smooth, stiff cotton material so thin and sheer as to be almost transparent. In high-grade qualities the finish is permanent. In cheaper grades the finish is destroyed by laundering. Used for dresses, trimmings, etc.

Outing flannel. A soft cotton material napped on both sides. White or yarn dyed. Many qualities. Used for sleeping garments, diapers, and infants' wear.

Palm Beach cloth. One of the varieties of mohair materials. At times popular for men's summer suits. *See* Alpaca.

Panama. A smooth, wiry wool material of plain weave. Used for skirts, dresses, suits, etc.

Parachute silk. A strong silk manufactured especially for aircraft use.

Paraffin duck. Canvas or duck treated with a paraffin preparation. Stiff, heavy, and waterproof. Used for coats and trousers by loggers, lumbermen, hunters, fishermen, etc.

Percale. A smooth, closely woven cotton material, usually printed. Has replaced high-grade calico or print. Used for house dresses, aprons, and children's wear.

Percaline. A light-weight, much-sized cotton material with high polish on face. White and plain colors. Used for linings.

Pile fabrics. A general term for all materials having a raised surface of loops or cut ends on one or both sides. Examples: bath towels, velvet, textile furs.

Pineapple, or *piña, cloth.* A thin, stiff, almost transparent material with a high luster. White or plain colors. Made in the Philippine Islands from pineapple fiber. Used for curtains and decorative household purposes.

Plissé (plĭ sā′; plē sā′), "pleated." A soft, fine cotton material with irregular puckered spots over the surface. Permanent effect produced by mercerization. Does not require ironing. White, printed, or in plain colors. Used for underwear and children's clothes.

Plush. A fabric having a long, straight pile on one side. Made of silk, wool, cotton, or a mixture. Used for millinery and trimmings. Plush made of mohair is used especially for upholstery in boats, cars, automobiles, etc.

Pongee. A strong, rough, dull silk material, usually tan-colored. Most frequently made from wild silk, which does not readily bleach or dye. There are many grades, some called Shantung, Rajah, Tussah. Also made of mercerized cotton and mixtures. Used for blouses, shirts, pajamas, suits, dresses.

Poplin. A corded material made with fine warp and coarse filling. May be of silk, cotton, wool, and mixtures. Many grades. Used for suits, dresses, trimmings, hangings.

Press cloth. A strong material usually made of cotton or linen and the beardlike camel's hair. Used for filtering.

Print. A general term for calico and other low-grade printed cotton materials.

Queen Anne satin. A sports silk similar to Baronette satin. *See* Baronette satin.

Rajah. See Pongee.

Ratiné (ra tee nay′). A rough, loosely woven cloth of cotton, silk, or wool made of specially prepared knotted yarns. Plain weave. Used for suits and dresses.

Rayon. The name officially recognized by the Federal Trade Commission as the generic name for all synthetic fibers made from cellulose. First called artificial silk. *See* Artificial silk.

Rep. A heavy ribbed material made with fine warp and heavy filling. Ribs larger than in poplin. Found in silk, cotton, wool, and

mixtures. Many weights. Light weights used for dresses, suits, and wraps; heavy, for draperies and upholstery.

Sailcloth. See Duck.

Saraceta. The trade name of a certain firm for its rayon products made by the cellulose-acetate process.

Sateen. A smooth, high-lustered cotton fabric in satin weave. White, dyed, and printed. Used for slips, bloomers, linings, and comforters.

Satin. A smooth silk material, made in satin weave, having high luster. Many grades, weights, and variations in weave. May have cotton or wool back. Many trade names given to different varieties. *See* Charmeuse *and* Baronette satin. Used for blouses, gowns, millinery, underwear, etc.

Satin damask. A damask in plain satin weave. *See* Damask.

Scrim. A coarse cotton material with open weave. Many grades. Used for curtains.

Seco silk. A lining material made of cotton and spun silk. Similar to A B C silk.

Serge. A firm, strong wool material made with the standard 2–2 twill weave. May be coarse, harsh, and wiry, as some storm serges, or fine and soft, as certain high-grade dress serges. Many grades and weights. Also found in silk, cotton, and cotton-and-wool mixtures. A fabric of universal use, always to be found. Used for suits and coats for men and women, caps, skirts, dresses, etc.

Serpentine crêpe. A cotton crêpe with irregular lengthwise lines and ridges produced by mercerization and calendering. Usually printed in gay and elaborate designs. Used for dressing sacques, kimonos, etc.

Shantung. See Pongee.

Sheeting. A firm, plain-woven cotton (or linen) material. Varies in width from 36″ to 108″. Used for sheets and pillowcases.

Shirting silk. See Wash silk.

Shot silk. A two-toned silk material made with warp of one color and filling of another. Called two-toned silk, glacé silk, changeable silk. Used for millinery, trimmings, gowns, etc.

Shower-proof foulard. Foulard with a special finish to prevent water spots. *See* Foulard.

Sicilian. See Alpaca.

Silkaline. A thin cotton material, dyed or printed, with a high polish on the face. Polish does not endure laundering. Used for comforters and decorative household purposes.

Sniafil. An artificial (rayon) wool. Used in wool mixtures.

Soisette (swȧ sĕt′). A fine, smooth, plain, highly mercerized cotton material. White or dyed. Used for shirts, pajamas, linings, dresses, etc.

Sports silk. A general name for strong, heavy silks with a somewhat conspicuous weave, color, or finish. Most commonly made with artificial silk. Used for sports skirts, suits, etc.

Stafford cloth. A two-toned mercerized cotton material used for curtains.

Stork sheeting. A light-weight, rubberized cotton fabric used for infants' pants, crib sheets, and toilet purposes.

Striped dimity. Dimity having a heavy cord at regular intervals in the warp. *See* Dimity.

Surgeon's gauze. See Cheesecloth.

Swiss. A crisp, sheer cotton material of plain weave. Plain or having woven dots or figures. *See* Dotted Swiss.

Taffeta. A plain, closely woven silk material, alike on face and back, usually finished so as to be crisp or stiff. Many grades. Also found in cotton. Used for dresses, suits, and millinery.

Tapa, or *Tappa*, *cloth.* A fabric of ancient origin made by hammering into a sheet the inner bark of a tree. Probably made by the natives of the South Sea Islands long before weaving was invented.

Tapestry. A thick, closely woven yarn-dyed material made on the Jacquard loom. Originally hand woven, each color in the design being woven with a separate bobbin. Found in wool, cotton, silk, and mixtures. Used for draperies and upholstery.

Tapestry Brussels. A lower grade of Brussels carpeting with printed instead of yarn-dyed pattern.

Tarlatan. A thin, plain, highly sized cotton material of open weave. Used for millinery, fancy dress costumes, etc.

Terry cloth. A cotton or linen material with a looped pile on one or both sides. Heavier weights called Turkish toweling and used for towels, bathrobes, slippers, etc. Lighter weights dyed or printed on both sides and used for draperies.

Transparent velvet. A beautiful light-weight velvet with silk foundation and rayon pile. *See* Velvet.

Tricolette (trĭ cō̇ lĕt′). A plain-knitted material, usually in tubular form, of artificial silk. White or in plain colors. Used for blouses and gowns.

Tricotine (trĭ cō̇ tēn′). A firm, soft, smooth wool material with fine double diagonal lines on face. Effect produced by special modification of twill weave. Used for suits and dresses.

Tub silk. See Wash silk.

Turkey red. A plain, unsized cotton material of a brilliant red color, practically fast. Originally colored with vegetable dyes from Turkey. Used for cushions, trimmings, etc.

Turkish towels. Special widths of Terry cloth used for towels. *See* Terry cloth.

Tussah. See Pongee.

Tweed. See Homespun.

Umbrella silk. Silk or a mixture of silk and cotton or silk and linen treated so as to be waterproof.

Vegetable silk. See Artificial silk.

Velour. A general term for a large variety of materials with pile or heavy nap on the face. Wool velour is a soft, warm material used for dresses and coats. Silk and cotton velours resemble velvet. Used for trimmings, millinery, draperies, cushions, and upholstery.

Velvet. A lustrous material of silk or cotton and silk, with short pile on the face. Many grades. Used for millinery, suits, dresses, trimmings, etc.

Velveteen. A cotton pile fabric made in imitation of velvet. Many grades. Used for same purposes as velvet.

Venetian. See Farmer's satin.

Vicuña. A soft, warm, wool material, originally made of wool from the vicuña. Now made from any fine, soft wool. Used for coats, blankets, robes, etc.

Visca. An artificial (rayon) straw. Made into fancy braids and used in millinery.

Viyella flannel. A fine, light-weight flannel made of wool and cotton, the two fibers being mixed in the yarn. Launders easily and shrinks little. Used for shirts, blouses, sports wear, infants' wear.

Voile. A smooth, firm, somewhat open material of plain weave, made with hard-twisted yarns. Found in silk, cotton, wool. Many grades. White, dyed, or printed. Used for gowns, curtains, trimmings, etc.

Wash silk. A soft silk with little or no weighting or face finish. Yarn-dyed or piece-dyed in delicate colors. Endures laundering. Also called tub silk, shirting silk. Used for shirts, blouses, and lingerie.

Webbing. A strong, closely woven, narrow cotton material much used during the World War to replace leather belts and straps. Also found in silk, linen, and mixtures. Used for suspenders, garters, etc.

Whipcord. A firm, smooth material of wool, cotton, or a mixture, with conspicuous diagonal cords across the face. Used for suits and coats.

Wilton rugs. Carpeting with deep cut pile on both sides.

Wood silk. See Artificial silk.

Wool nap. A trade name for the thick, fleecy nap on a certain kind of cotton blanket.

Woolens. General term for soft wool materials.

Worsteds. General term for firm, smooth wool materials. Generally made of hard-twisted worsted yarns.

GLOSSARY OF TERMS

Bast fiber. The long, strong fibers lying directly under the outer bark of various plants, as flax, hemp, jute, ramie, etc.

Batik. A process, invented by the Javanese, of resist coloring with the use of melted wax.

Battening. Beating the filling yarns close together in weaving.

Beetling. A process of hammering the surface of cloth (particularly damasks) so as to flatten the yarns, thereby increasing the luster.

Bleaching. The process of extracting the natural coloring matter from materials, leaving them white.

Bleeding. The running of colors in dyed materials.

Blending. A mixing of different kinds or colors of fibers to produce a desired yarn.

Block printing. The stamping of color on cloth by hand with carved wooden blocks.

Boiled-off silk. Silk from which the gum has been removed.

Breaking. The crushing of the straw of flax (hemp, jute, ramie, etc.) to loosen the bast fiber from the outer bark and woody tissue of the plant.

Broad silks. A term applied to dress silks and linings of common width, to distinguish them from wide ribbons and silks of very narrow widths.

Burling. The removal of knots, burrs, etc. from the surface of cloth during the finishing process.

Burnt-out process. The process of removing a textile material by means of a chemical which destroys or burns out the fabric. Used particularly with imitation Venise lace.

Calendering. A term used for pressing cloth with heavy rollers during the finishing process, to give it the desired polish.

Carbonizing. The removal of foreign substances from fibers or cloth by burning out with chemicals. The process is used particularly for destroying vegetable matter in wool or wool materials.

Carding. Untangling and straightening out textile fibers.

Chemical bath. The chemical solution into which certain kinds of fiber or cloth are submerged during the manufacturing process, to produce permanent changes.

Clipping. Cutting the long fibers on the surface of cloth to make them of equal length. Process used particularly with broadcloths and pile fabrics.

Cloth glass, or *Cloth tester. See* Weaver's glass.

Combing. A process following carding to still further straighten out the fibers and lay them parallel. Used particularly with wool for worsteds and with long-stapled cotton for fine goods.

Composition dots. Spots of colored or white paste deposited on the face of cloth to make the pattern. More effective for certain materials than printing.

Count of cloth. The number of warp and filling yarns in a square inch of material. The weight and fineness of cloth can be judged by the count.

Count of yarn. The fineness to which it is spun.

Courses. The horizontal ridges in knitted materials made by the tops of the stitches as they have been thrown off by the needles in the knitting process.

Cravenetting. Treating fibers or fabrics with a chemical substance to make them moisture resistant.

Crock. The rubbing off of color from a dyed material. Cheap colored hosiery and linings sometimes crock.

Crofting. Bleaching on the grass. A term used particularly in the British Isles.

Cross dyeing. The dyeing of a material containing both animal and vegetable fibers with a dye which colors only one kind of fiber. Wool and cotton mixtures are often cross dyed.

Cut of cloth. An old expression for "bolt of cloth," or the lengths into which the entire woven piece is cut.

Decortication. The cleaning of the bark and woody tissue from the fiber of the plant. Term used especially in the manufacture of ramie and hemp.

Denier. A French unit of weight of about 5 centigrams. Used in determining the size, or "count," of silk and rayon yarns.

Direct printing. The stamping of color on the surface of the material.

Discharge process. The printing of a pattern with chemicals on the surface of a dyed fabric. When the cloth is submitted to the proper after treatments, the color will be removed, or discharged, from these printed spots. White patterns on dyed cotton materials are frequently obtained by the discharge process.

Doctor knife. The instrument in a printing machine which removes all extraneous coloring substance from the carved roller which is to stamp the pattern on the cloth.

Doubling. The process, in the manufacture of yarn, in which many slivers are drawn into one. The more times this doubling process is performed, the more thoroughly the fibers are mixed and blended.

Down hair. The soft, fine undergrowth of hair. Certain animals, as goats and camels, produce both coarse beard hair and fine down hair.

Drawing. Pulling out, or attenuating, the big, soft rope of fibers, as it leaves the card or comb, into the desired size of yarn.

Dressed flax. The cleaned flax fiber that is ready to be spun into yarn.

Dressing. The substance used in the finishing of cloth to give it the proper weight, stiffness, or polish.

Duplex printing. The printing of a pattern on both the face and the back of a fabric.

Duplicate printing. The printing of both the face and the back of a fabric with the pattern as accurately placed as if the design had been stamped through. Duplicate printed materials can easily be mistaken for warp-dyed goods.

Dyeing. The coloring of a material by immersion in a color bath. *See* Cross dyeing, Stock dyeing, *and* Tie dyeing.

Dynamiting. Increasing the weight of silk by dipping it into a mineral solution. The process is also called weighting or loading. A small amount of loading is not injurious to the fiber. A large amount greatly weakens it.

Emerizing. Raising nap on the surface of goods by emery-covered rollers. Chamoisette for gloves, duvetyn, and materials with a "peach bloom" surface are emerized.

Ends. A mill term for warp yarns.

Face of cloth. The right side as distinguished from the wrong.

Feel of cloth. A mill and trade term to describe the character of cloth as determined by handling. The expression "leathery feel" is used especially with table linens.

Felted. See Fulled.

Filatures. Machines for reeling silk mechanically.

Filling. The common name for the yarns carried by the shuttle across the warp in weaving. Old terms for these yarns are *woof* and *weft.* The mill term is *picks.*

Filling. The powder, starch, or clay used in the finishing process to increase the weight or fill the interstices in coarse or loosely woven cloth. Cheap cottons, linens, and pongees often contain much filling.

Fixed. A term used in dyeing or printing when the colors are made permanent or fast.

Flax brake. The machine or implement used for breaking the flax straw so that the woody substance can be cleaned from the fiber. Breaking is the first process in flax preparation after retting.

Floats. The long yarn, either warp or filling, exposed on the surface of cloth in weaving. These floats give smoothness to satins, sateens, plain damasks, etc. and beauty to pattern weaving.

Flocks. The short fiber ends that are clipped off the surface of wool materials and napped goods in the finishing process.

Fulled. A term used in the manufacture of wool materials when they are reduced in width and length. Other terms for the same process are shrunk, milled, felted.

Full-fashioned. Term used of knitted underwear and hosiery. In full-fashioned garments flat, shaped pieces are knitted and then sewed together to form a permanently shaped garment. Circular knitted garments are knitted in tubular form and then shaped by pressing.

Garnetting. The tearing of manufactured materials into fibers. One of the first processes in securing wool for remanufacture.

Gassing. The removal of the short fiber ends on the surface of yarn or cloth by burning. Used particularly with cottons. Another term for the same process is *singeing.*

Hackle. See Hetchel.

Hackling. One of the early processes in the cleaning of flax. After the breaking process the flax is drawn by hand or machine over combs which rake out the woody tissue and separate the flax fibers.

Harness. The part of a loom which controls the lifting of the warp yarns.

Hatchel. See Hetchel.

Healds. One of the cords or wires of which the harness is made. Each heald carries one warp yarn. Sometimes called heddles.

Hetchel. A tool with long teeth through which flax is drawn when dressed by hand. Also called hatchel and hackle.

In the gray. A mill expression for the woven cloth before it has been bleached or colored.

In the rough. When flax fiber is partly cleaned but still tangled and dirty, it is spoken of as in the rough.

Kemp. The coarse, dead wool fibers in a fleece. These do not manufacture well.

Lap. A mill term for a wide sheet of fibers before it is drawn out into slivers.

Lease eye. The eye in the center of the heald, through which the warp yarn is drawn.

Line. The long, straight fibers of dressed flax which have been separated from the broken, tangled ones in the cleaning process.

Linen glass, or *Linen tester. See* Weaver's glass.

Lint. Cotton fiber after ginning.

Linters. Cotton seeds to which considerable fiber still clings after the ginning process.

Loading. See Dynamiting.

Mangling. Ironing cloth or garments between rollers. A laundry term.

Mercerizing. A chemical process used with cotton. Mercerizing straightens and plumps the cotton fiber, causing it to be more lustrous and take dye better. Mercerizing correctly done strengthens the cotton fiber.

Mill waste. A general term for the by-products of various mill operations.

Milled. See Fulled.

Mordant. A chemical used with some kinds of dyes to increase their affinity for the fibers.

Mungo. Term applied to the lowest class of remanufactured wool.

Napping. Pulling the ends of the fibers to the surface of the cloth to form a fuzz or pile. When done with teazels the process is called teazling. Broadcloth and outing flannel are examples of napped goods.

Noils. The broken and tangled fibers left when wool is combed for making worsteds, or silk for making spun silk.

Nub yarn. A kind of novelty yarn.

Organzine. The fine, strong silk yarn used for warp.

Pantograph. A machine for cutting the pattern on the copper rollers used in printing.

Perching. A mill term for one of the inspections of cloth during its manufacture.

Pick. One of the filling yarns in cloth.

Pick glass. See Weaver's glass.

Picking. The work of the shuttle as it carries the filling yarn through the warp yarns in weaving.

Ply. One of the several yarns which are twisted together to form a coarser yarn or sewing thread.

Pure dye. A term used with dyed silks to show that there has been little or no weighting used.

Raw material. Textile fibers which have not been through any manufacturing process.

Reclaimed wool. Wool fiber taken, or reclaimed, from manufactured materials. Commonly called shoddy.

Reeling. Winding off the fiber from silk cocoons.

Remanufactured wool. See Reclaimed wool.

Resist process. A method of dyeing whereby certain parts of the material are covered with a wax or paste which is resistant to the dye. This process is used in batik printing and, to a certain extent, in commercial printing.

Retting. The decomposition, or rotting, of the woody tissues in bast fibers.

Reworked wool. See Reclaimed wool.

Rippling. The removal of the leaves, seeds, and roots from the flax plant. The first process in the preparation of flax for manufacture.

Roughing. One of the early operations in the cleaning of flax fiber.

Roving. One of the later stages of yarn manufacture as the yarn is being drawn out for spinning.

Schreinerizing. A process whereby a beautiful luster is given to cloth by the use of etched rollers. This luster will not survive laundering.

Scutching. The first cleaning of flax fiber after the breaking process.

Seaming. Removal of the seams and other stitched parts in materials that are to be garnetted.

Seconds. Materials containing imperfections.

Setting of colors. Making colors permanent, or fast.

Shedding. A term used in weaving to describe the opening in the warp yarns for one passage of the shuttle.

Shoddy. A common name for all reclaimed wool.

Shrunk. See Fulled.

Singeing. See Gassing.

Singles (*s*). One of the several yarns which are twisted together to make thread or a coarser yarn.

Sized. Stiffened or starched.

Skirting. The removal of the tag ends and torn edges from a fleece.

Sliver. One of the ropelike stages into which yarn is drawn in the process of manufacture.

Slubbing. A stage in the manufacture of yarn before it is drawn into roving.

Souple silk. Silk material from which only a part of the gum has been removed.

Spinnerets. The two holes in the head of the silkworm through which he ejects the silk fiber.

Spread board. The machine, used in linen manufacture, on which the dressed flax is placed, or spread, for the first drawing process.

Spun silk. Silk or silk materials made from pierced cocoons, and all other forms of waste silk which cannot be reeled but must be spun into yarns.

Spun rayon. Yarn made from the short and broken fibers in the manufacture of rayon.

Staple. A term used for fibers when measured in a mass.

Staple fibers. Rayon fibers cut into uniform lengths of a few inches. Used for spun rayon or to mix with other fibers.

Staple materials. Materials so useful as to have become a permanent necessity. Examples: Crash, broadcloth, percale.

Stock dyeing. The dyeing of the fiber, or stock.

Stretch spinning. A term used in the manufacture of rayon when fine filaments are made by stretching larger filaments in the coagulating bath.

Synthetic fiber. A chemically made fiber. Rayon.

Tag locks. The dirty, stained portions around the edges of a fleece.

Teazeling. See Napping.

Tender. A mill expression the same as *weaken* when used in connection with the injurious effect of poor bleaching.

Tentering. The stretching of cloth to width in a tenter frame.

Throwing. The doubling and twisting of reeled silk into yarn.

Throwsters. In silk manufacture the operatives who do the throwing are called throwsters.

Tie dyed, or *tied and dyed. See* Tie dyeing.

Tie dyeing. Producing a pattern by winding string around certain parts of the cloth before it is dyed. The string prevents the dye from acting on those spots, which remain their original color.

Tin pants. A general name among loggers and lumbermen for trousers so treated with a paraffin preparation as to be hard, stiff, and impervious to water.

Topping. A process, in dyeing, in which a dyed material is dipped into a bath of a different color.

Tops. The large, soft balls of combed wool fiber.

Tow. The short, tangled flax fibers that are combed out in the dressing process. *See* Line.

Tram. Yarn used for the filling in silk weaving. It is usually coarser and has less twist than the organzine, or warp.

Twin-needle stitch. A mill and trade term for the one-and-one rib stitch in knitting.

Two-ply. A term applied to yarn or thread in which two strands, or singles, are twisted together.

Virgin wool. Wool that has never before been manufactured.

Wales. The up-and-down lines in knitted materials formed by the sides of the stitches. *See* Courses.

Warp. The yarns in woven cloth running lengthwise of the piece.

Weaver's glass. A small magnifying glass used for a close examination of cloth or yarn. Also called cloth glass, pick glass, linen glass, linen tester, cloth tester, etc.

Weft. See Filling.

Weighting. See Dynamiting.

Whorl. The weight at the bottom of a hand spindle.

Wild silk. Silk made by worms that cannot be domesticated. Many of the rough silks, like pongee and Shantung, are made from this fiber.

Woof. See Filling.

Wrought-knitted goods. Garments that are made of flat pieces wrought or knitted to shape. Full-fashioned hose are made of such pieces.

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